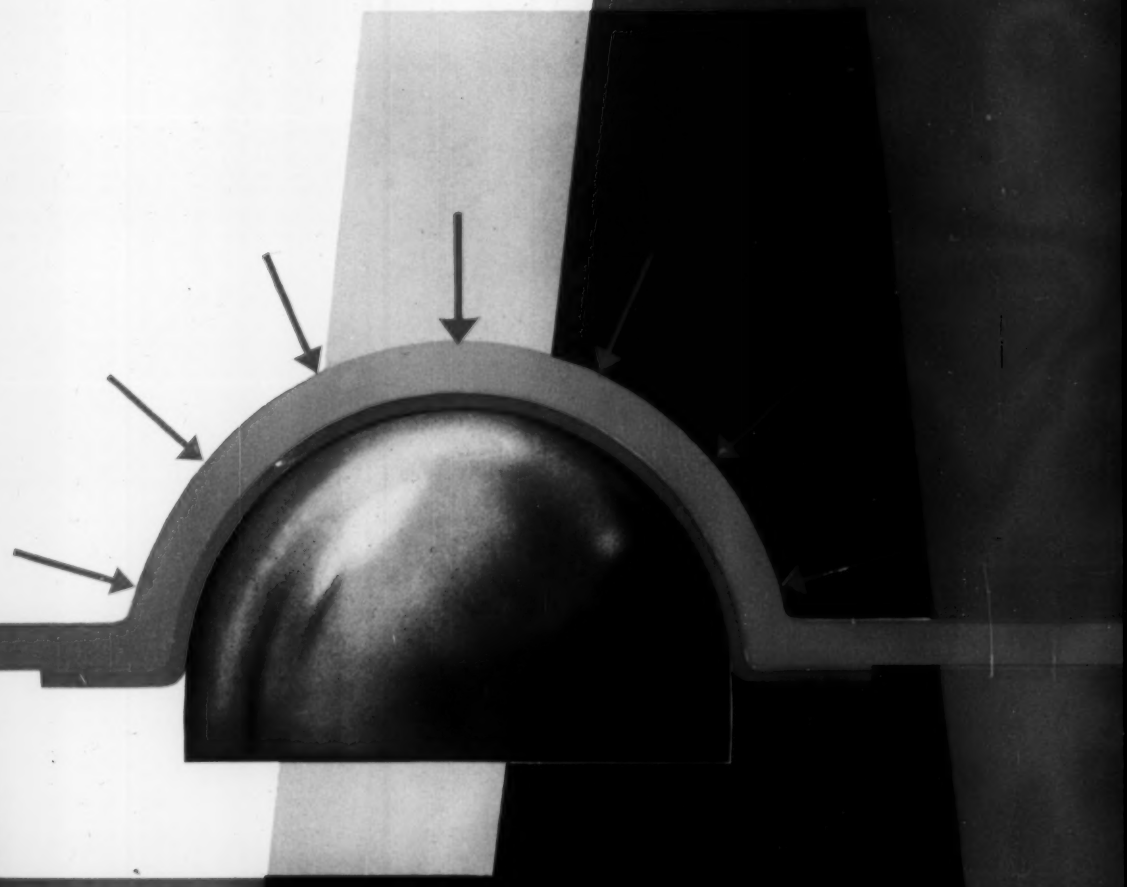
JUNE 27, 1957

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY



HYDROFORMING

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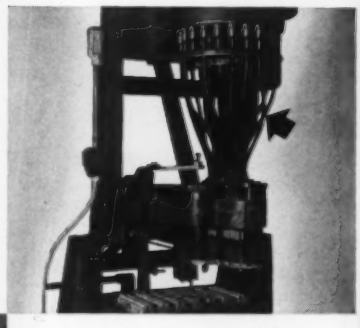
S.S.White

Flexible Shafts Step Up Design Efficiency

The manufacturer of this multiple spindle drill press finds that S.S. WHITE FLEXIBLE SHAFTS allow a wide range of positions for different drilling jobs.

This is only one example of the versatility . . . efficiency . . . and freedom S.S. WHITE FLEXIBLE SHAFTS are bringing to hundreds of industrial designs. The restrictions imposed by rigid shafting are eliminated. With flexible shafts you position power sources . . . driven members . . . controlled parts to better advantage. By simplifying methods of connection and adapting, costs can be reduced. Assembly is cheaper . . . alignment problems are eliminated . . . and product efficiency is often greatly improved!

Consider your own product. Chances are, S.S. WHITE FLEXIBLE SHAFTS are the simple, economical answer to your power drive and control problems. S.S. WHITE FLEXIBLE SHAFTS are noted for quality, performance and dependability. For more information and expert assistance in selecting and applying an S.S. WHITE flexible shaft to your product, just write to



S.S.White

FIRST NAME IN FLEXIBLE SHAFTS

USEFUL DATA on how to select and apply flexible shafts! Write for Bulletin 5601.

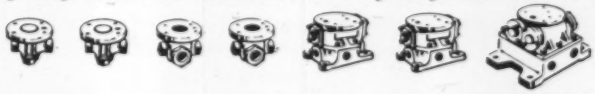
S. S. White Industrial Division, Dept. 4 10 East 40th St., New York 16, N. Y. Western Office: 1839 West Pico Blvd., Los Angeles 6, Calif.

Circle 401 on page 19.

Ross Skyline

Silvermodel JIC Spool Solenoid

Any Skyline Head Attaches to Any Skyline Valve Body



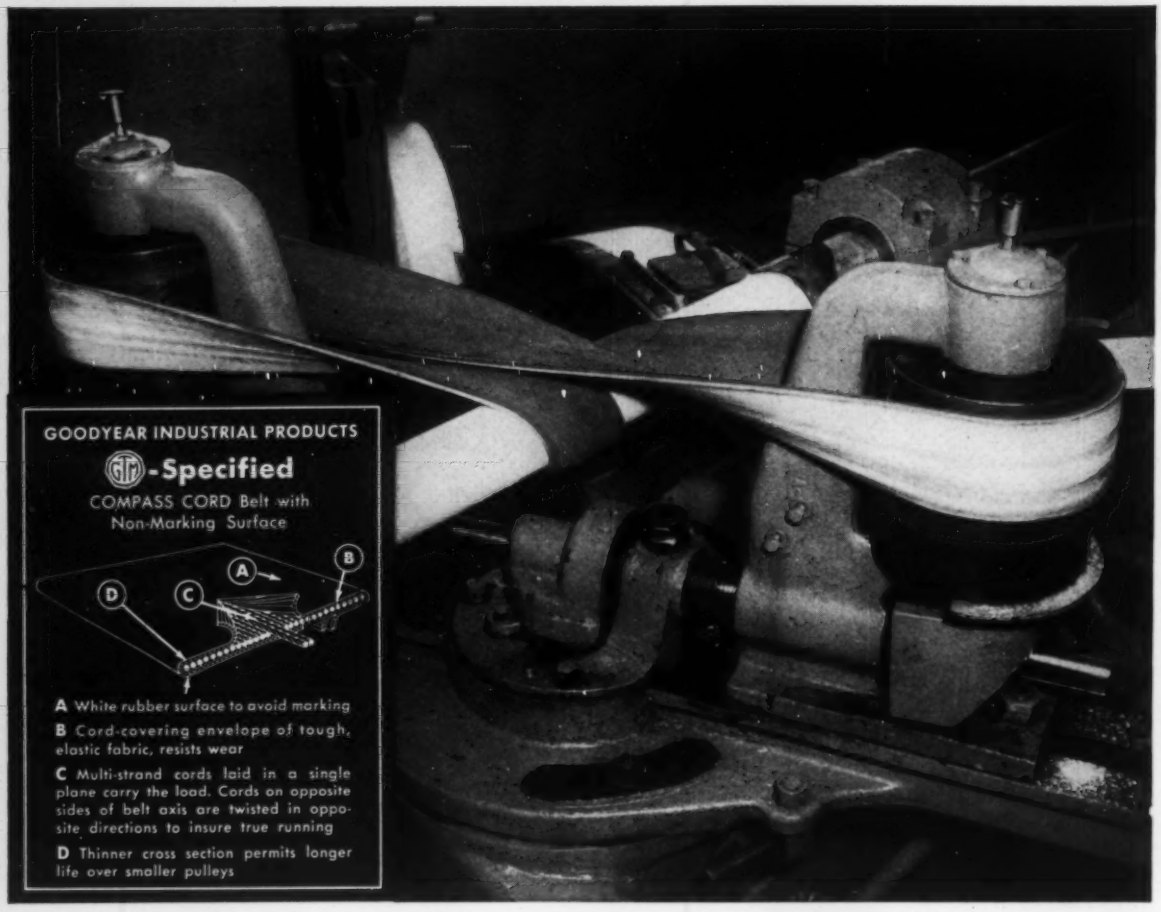
Interchangeable! 25 Million Cycles in Tests!

Now the JIC spool solenoid valves join the Ross Skyline. Now six actuating heads and seven in-line and base mounted bodies—all completely interchangeable—give you any valve you want in this series designed especially to last millions more cycles than ordinary valves. But, these quality valves come to you at *sensible* prices! For instance, the 3/8" Silvermodel base mounted, 4-way is only $62.50 complete, and complies with all JIC requirements. Write for bulletin 315.

Ross OPERATING VALVE COMPANY

109 EAST GOLDEN GATE AVENUE • DETROIT 3, MICHIGAN

Circle 404 on page 19


GOODYEAR INDUSTRIAL PRODUCTS
G.T.M.-Specified
COMPASS CORD Belt with Non-Marking Surface
A
B
C
D
A White rubber surface to avoid marking
B Cord-covering envelope of tough, elastic fabric, resists wear
C Multi-strand cords laid in a single plane carry the load. Cords on opposite sides of belt axis are twisted in opposite directions to insure true running
D Thinner cross section permits longer life over smaller pulleys

Beats old belt by a clean 800%

An expensive custom-built belt was first choice for the tough, twisting, quarter-turn drive on this tube winder. But it left smudging marks on the cylindrical containers the machine turns out. And within six months that belt gave out entirely.

Then the G.T.M.—Goodyear Technical Man—offered his solution: A COMPASS CORD Belt engineered to shrug off twisting strains—and with one side covered with non-marking white rubber.

At last check, the G.T.M.'s belt had handled its tough job for 4 solid years. It's never left a mark on a single container. And it's still going strong!

Little wonder the G.T.M. is called in to solve so many tough industrial rubber problems. Remember – you can always reach him *in a hurry* by contacting your Goodyear Distributor or writing:

Goodyear, Industrial Products Division
Akron 16, Ohio

COMPASS CORD BELT by

GOODYEAR

THE GREATEST NAME IN RUBBER

IT'S SMART TO DO BUSINESS *with your Goodyear Distributor. He can give you fast, dependable service on Hose, V-Belts, Flat Belts and many other industrial rubber and nonrubber supplies. Look for him in the Yellow Pages under "Rubber Goods" or "Rubber Products."*

Compass—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

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June 27, 1957
Volume 29—No. 13
THE PROFESSIONAL JOURNAL FOR ENGINEERS AND DESIGNERS
MACHINE DESIGN

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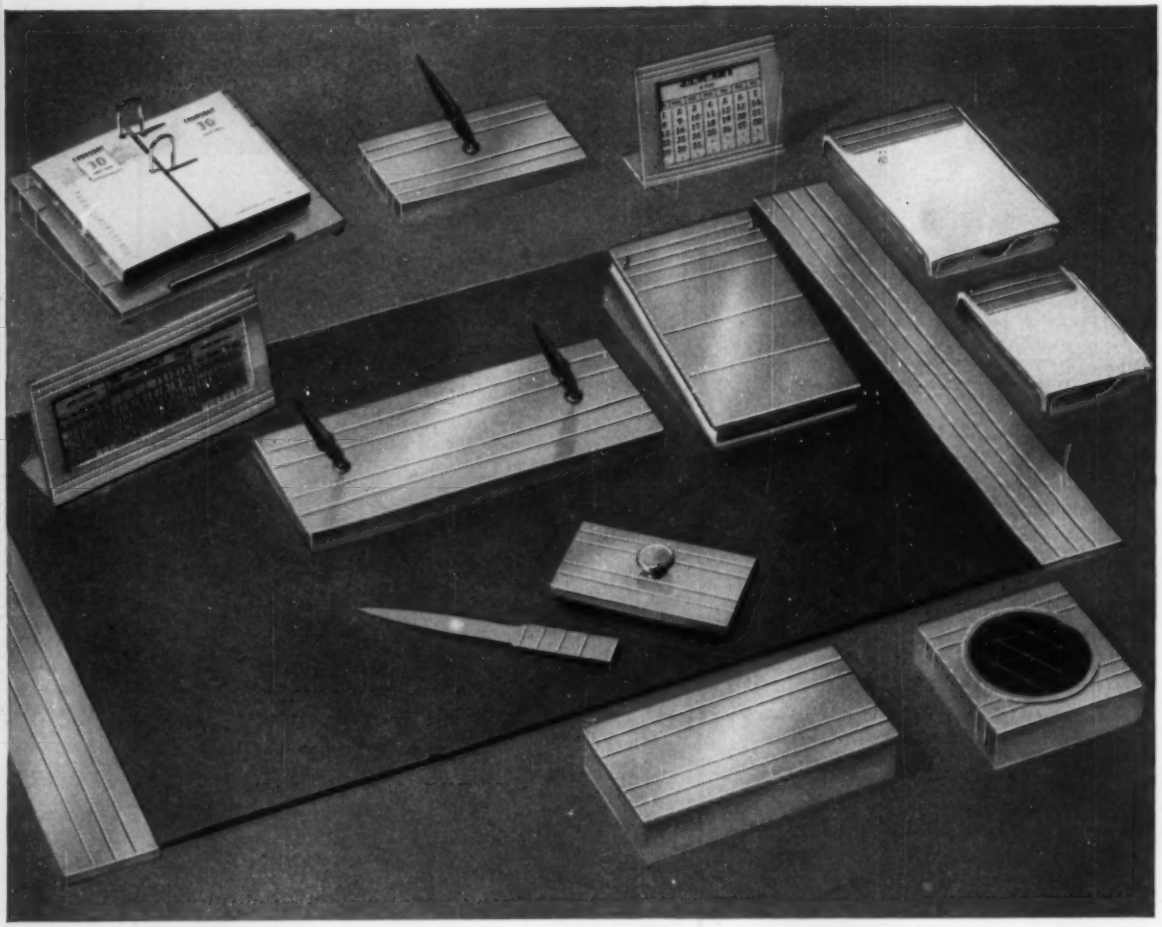
Published every other Thursday and copyrighted 1957 by Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.



A few of the fine executive desk appointments made of Formbrite by Smith Metal Arts Co., Inc.

For a superfine luster that lasts—superfine-grain Formbrite

Smith Metal Arts Co. uses easy-to-polish, scratch-resistant Formbrite to add value to its line of distinguished desk appointments.

The fine executive desk appointments made by Smith Metal Arts Co., Inc., Buffalo, N. Y., are not just polished to shine. They are brought up to a beautiful deep luster. For their line of brass accessories they use Formbrite,® Anaconda's superfine-grain drawing brass.

They have found that the fine, uniform grain size of Formbrite enables them to give their pieces a superior, more uniform texture. The luster, furthermore, stands up better under handling because Formbrite provides a harder, more scratch-resistant surface.

In order to achieve this fine luster, Smith Metal Arts Co. must do an exceptional amount of polishing and they have chosen Formbrite because of its superior polishing characteristics. By using Formbrite they can achieve their high quality surfaces at savings of 20% over the use of ordinary brass.

See for yourself. Formbrite is a premium product at a nonpremium price. Find out for yourself how its superfine grain, excellent drawing properties, strength, and scratch resistance can help you improve product quality, lower finishing costs. Write for Publication B-39. Better yet, ask for a sample or details on our trial order offer. Address: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 5771

Formbrite

SUPERFINE-GRAIN DRAWING BRASS

an ANACONDA® product

Made by The American Brass Company

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Engineering News Roundup

Refining Process May Cut Cost of Titanium, Alloys

Low Grade Ore to Yield High Grade Titanium Salt

CHICAGO, ILL.—Titanium and its alloys may soon cost less as a result of recent improvements in refining the metal from low grade ores. A new process announced by Armour Research Foundation, Illinois Institute of Technology, will produce titanium tetrachloride at less cost and higher purity than heretofore. Effect of the Armour development is to make more feasible the use of low grade titanium ores such as ilmenite.

The new process starts with a "cold chlorination" of ilmenite ore at freezing temperatures. The conventional process requires very high temperatures to chlorinate a high grade ore—rutile. Since about 4 lb of titanium tetrachloride are needed to produce 1 lb of titanium, use of the more expensive rutile in the old process contributes heavily to the cost of the end product.

Key reaction in the new method is the precipitation of potassium chlorotitanate from ilmenite solution and the decomposition of the precipitate into titanium tetrachloride and potassium chloride at candle flame temperatures.

NEW TWO-PLACE JET TRAINER under development by Northrop Aircraft Inc. is shown for the first time. Student and instructor are seated in tandem cockpits. Raised seat in the rear cockpit enables the instructor to check student's movements and reactions. "Coke bottle," or area rule configuration of fuselage indicates supersonic capabilities of the T-38. Design objectives were simple, lightweight construction, ability to operate from short runways and performance characteristics matching operational aircraft.

New Battery for Jet Planes Is Lightweight, Powerful

PHILADELPHIA, PA.—A lightweight silver-zinc battery designed to meet the special high-discharge requirements of jet planes has been developed by Electric Storage Battery Co. Designated the Exide 14-S-100, it features silver-oxide positives and zinc-sponge negatives as active plate materials. In specific conditions the battery is said to have 3 or 4 times the power output of conventional lead-acid

OUTBOARD MOTOR POWERS this one-man helicopter designed by Goodyear Aircraft Corp. Speed of 60 knots is furnished by a standard Johnson two-cycle water-cooled engine. Lightweight frame is welded aluminum tubing. In case of power failure, the helicopter is said to have excellent autorotation, allowing gradual descent. Intended for courier, liaison, or rescue service, the helicopter recently completed Navy flight tests.

aviation batteries on a comparable size and weight basis.

The new battery is capable of delivering repeated, sustained surges of power at high rates of discharge under normal and emergency conditions. In addition to operating accessory equipment, the battery energizes jet engine flow plugs in case of flame-out aloft.

WALKING BEAM SUSPENSION of front wheels on the Army's XM282 truck give a relatively comfortable ride in cross-country travel. The truck has demonstrated high mobility over rough ground, in mud, snow and sand; easily overcomes 60 degree grades and deep trenches. Rated 5-ton cargo capacity, the XM282 can be either a carrier or prime mover. Its weight is 15,500 lb; length, 22 ft; bed length, 15 ft; overall width, 96 in. Powered by 170-hp engine, XM282 attains 58 mph. All wheels drive. It is one of a series planned to make maximum use of standard military vehicle parts.

Missile Built Quick, Cheap, Simple with Present Knowhow

Navy's Light Attack Aircraft Will Carry 600-lb Bullpup

WASHINGTON, D. C.—Ruggedness and reliability were design objectives for a new air-to-surface missile — the Bullpup — recently announced by the Navy and the Martin Co. The weapon is currently undergoing evaluation tests and will soon join the active fleet.

Bullpup is designed to be launched from light attack aircraft outside the effective range of enemy high-volume fire. It will have sufficient accuracy to destroy small targets without the usual expenditure of large quantities of bombs and

Front Cover

Fluid forces form metal in the Hydroforming process, as suggested on George Farnsworth's front cover. Points to consider in designing Hydroformed parts are covered in Russ Beckim and H. H. Muller's article on Page 153.

. . . Fluid Power news

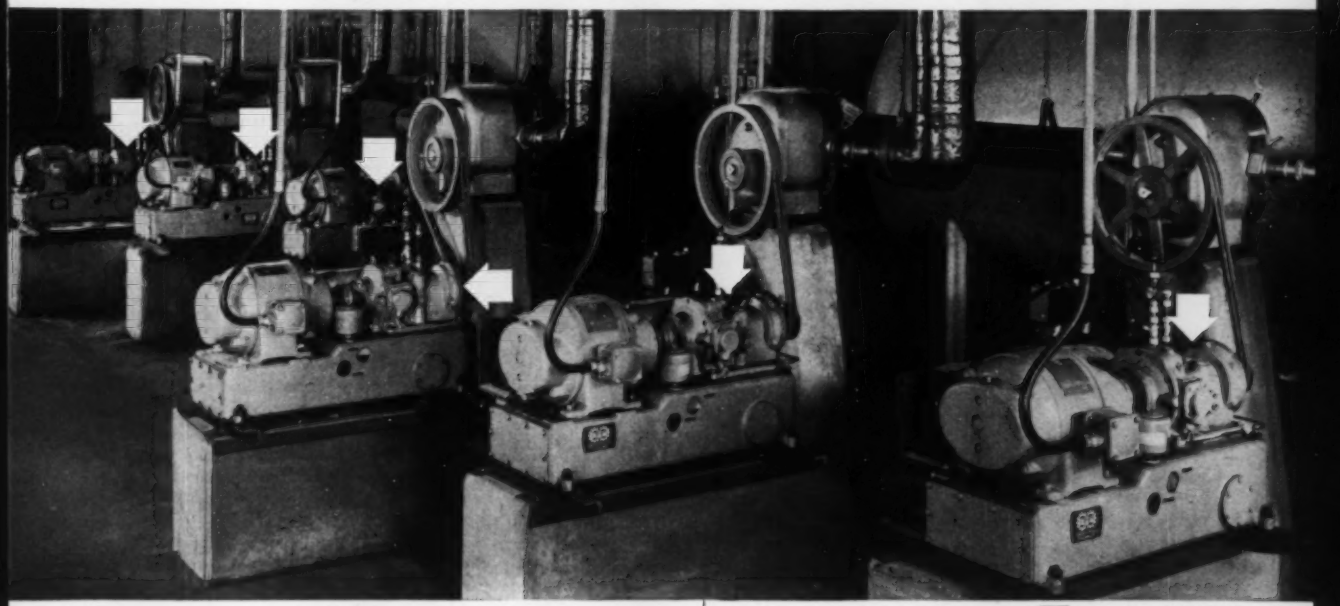
REPORT NO. 11,300 NEW LIQUID LEVEL CONTROL

From Oilgear Application-Engineering Files

HOW OILGEAR DRIVE AND CONTROL SYSTEM STABILIZED BEER FILLING LEVEL

CUSTOMER: *Large Western Brewery (Name withheld by request)*

DATA: Highly carbonated beverages must be handled gently. Throttling flow of beer into filling machine reservoirs causes foam and irregularity of liquid height, making accurate filling of cans or bottles difficult. These reservoirs are small compared to the flow through them. Costly losses are incurred on tax-paid cans "in process" due to under or overfilling. Any beer pump drive-control system must respond immediately, have smooth action, and be unaffected by daily washdowns required to maintain sanitary operations. Accurate automatic control, dependable operation, and ease of maintenance—as always—are important factors in the selection of this equipment.



SOLUTION: Shown "on the job" above, are 6 Oilgear AHB-33, two-way, "Any-Speed" transmissions driven by 3 hp electric motors, mounted on standard reservoir bases. Transmissions drive beer pumps through dual "V" belts. Beer is pumped from storage tanks to bottle or can filling machine reservoirs on the floor above. Liquid level in filling reservoirs is controlled automatically by a low pressure CO_2 signal . . . as level rises, pressure rises . . . as level falls, pressure falls. Translated to air pressure signals, which, transmitted to controls on Oilgear transmissions, automatically-instantly increase, decrease, reverse, or stop the beer pumps. Where former throttling system caused foam and irregular levels, this Oilgear system holds reservoir level to $\pm 1/16''$ under continuous operation . . . assuring accurate filling of each can or bottle. Beer pumps are flushed under water pressure without disconnecting drives. Several years of continuous service have proven drives to be extremely dependable under all conditions, with little or no attention.

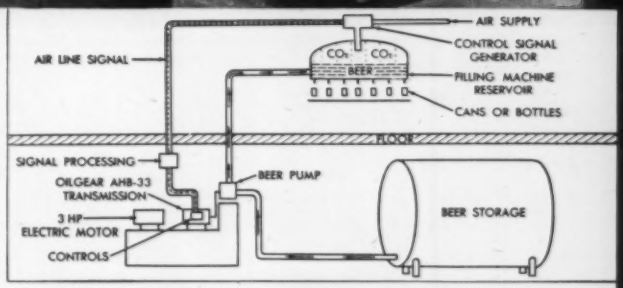
Oilgear Application-Engineering can also provide practical solutions to your linear or rotary drive problems. Call the factory-trained Oilgear application-engineer in your vicinity. Or write, stating your specific requirements, directly to . . .

THE OILGEAR COMPANY

Application-Engineered Fluid Power Systems

1568 WEST PIERCE STREET • MILWAUKEE 4, WISCONSIN

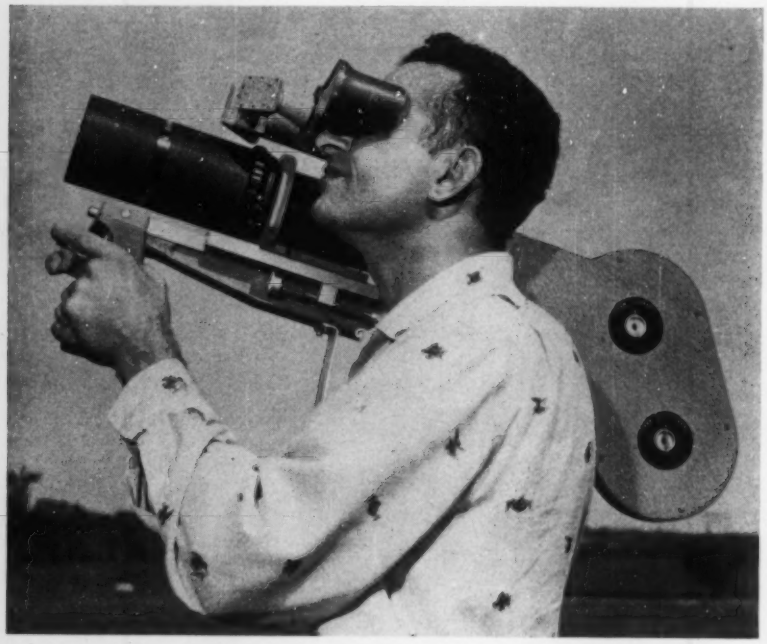
Please direct inquiries to advertiser, mentioning MACHINE DESIGN



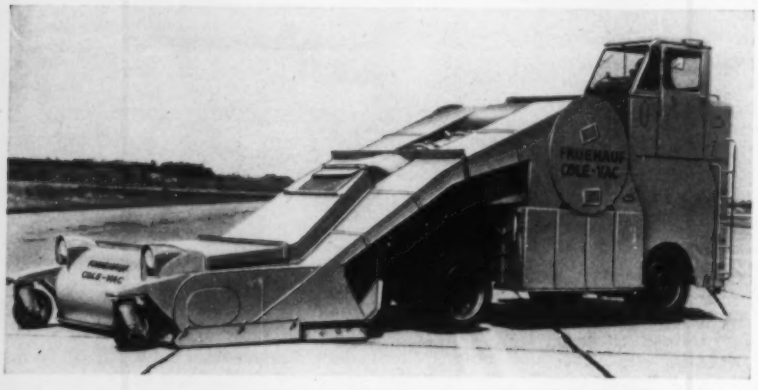
Similar Oilgear "Any-Speed" drives have improved performance on can closing, filling; paper, printing, textile, tape, and rubber processing machines; extruders, capstans, winders, stokers, centrifuges, gang-saw feeds, saw mill carriages, conveyors, and the like. They provide efficient conversion of any constant rotary motion to accurately controlled variable rotary motion . . . smooth, stepless, uniform acceleration from zero to maximum in either direction . . . manual, hydraulic, electric or electro-hydraulic controls—providing complete flexibility of location . . . low power consumption—using power only in proportion to work performed . . . durable, trouble-free, low maintenance due to simplicity and automatic lubrication of all rotating parts.

heavy rockets. Bullpup is 11 ft long; weighs 600 lb.

"Dive bombing with a college education" describes the use of the Bullpup. Major considerations in its development were design simplicity and the use of known techniques well within the state of the art to obtain an early, relatively inexpensive and effective weapon.



STEADIER PICTURES of fast-moving objects are obtained with this gun-type camera developed at the Naval Ordnance Laboratory. Slow-motion movies of low-altitude, high-velocity missile launching operations furnish engineers with performance data previously sought through instruments carried inside the ordnance. Camera weighs 25 lb and features through-the-lens sighting, 12 and 6-in. telephoto lens, accurate timing marks on the film, and variable focus between preset limits controlled during operation.



CLEAN SWEEP of airport runways is the function of this new vehicle, called Col-Vac, made by Coleman Engineering Co. and Fruehauf Trailer Co. At maximum cleaning speed of 25 mph, unit vacuums 1-million sq ft of runway per hour. Conventional truck chassis is reversed to place nozzle intake ahead of the basic vehicle. Rear-wheel steering provides high maneuverability. A separate motor powers the vacuum system, which is capable of picking up a variety of debris from sand to 2-in. rocks.

Topics

Talking pen, made in Japan, is really a portable radio. A plastic and celluloid model that looks like a fountain pen picks up stations "within reasonable distance" when the cap is turned. The radio has a built-in socket, one earphone and an antenna. No batteries are needed.

• • •

Listening to an air conditioner, which might prove annoying to human ears in a quiet room, is done by electronic measuring and recording equipment in a noise-level test setup at Carrier Corp. A Brush Electronics Co. Third Octave Pectrum Analyzer and Graphic Level Recorder measures noise made by room air conditioners as units on an assembly line pass through a soundproof room. To pass the test, measurement records must agree with a master specimen.

• • •

Unique radio telescope at the Naval Research Lab can operate at wavelengths shorter than 1 cm. It will be used to study radiation from the earth's cloud cover. Usually the radiation observed is heat extended to radio wavelengths and sounds like hissing. The radio telescope will also be used to study sunspots, flares and radiation from distant objects in the universe, as well as for the study of weather phenomena, cloud electrification and thunderstorm processes.

• • •

New products not now manufactured will account for 30 to 80 per cent of growth of major U.S. manufacturers in the next three years. This is an expectation found in a study of 400 industrial firms recently made by management consultants Booz, Allen & Hamilton.

• • •

First metal spring used to repair a human heart valve has proved effective in over a year's operation. Doctors from Wayne University Medical School and metallurgists and technicians at Elgin National Watch Co., perfected the spring, which is made from Elgiloy, a material used in watch mainsprings.

Circle 407 on page 19→

POROUS BRONZE BEARINGS

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POWDER METALLURGY BEARINGS + PARTS

OIL-IMPREGNATED BRONZE BEARINGS

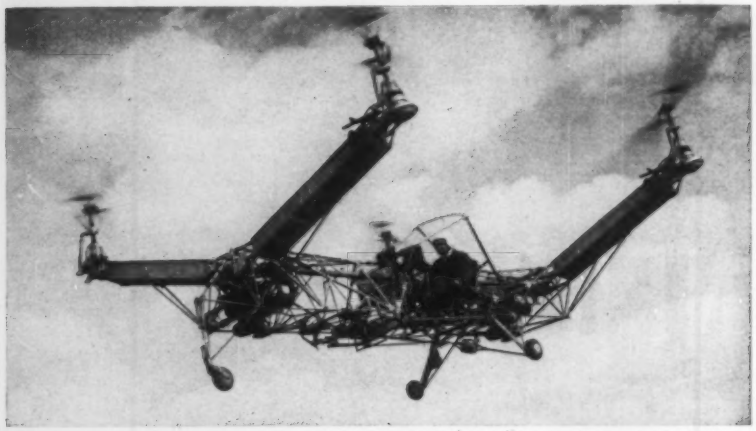
BRONZE OIL-LESS BEARINGS

POWDER METALLURGY BRONZE BEARINGS

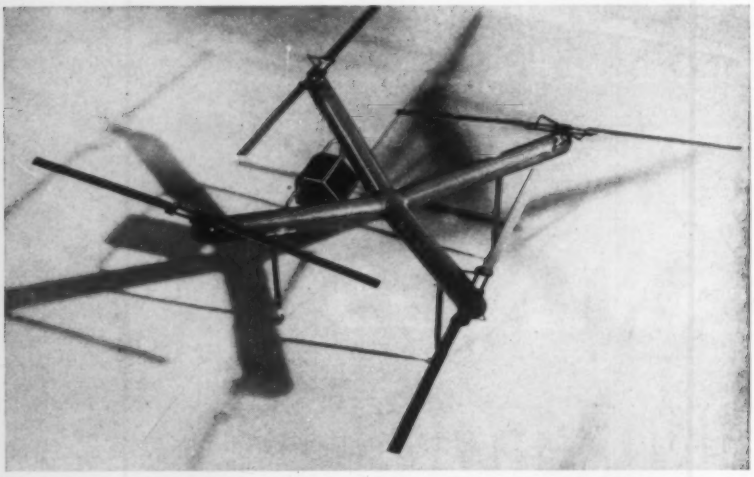
OIL-FILLED BRONZE BEARINGS

METAL POWDER BRONZE BEARINGS

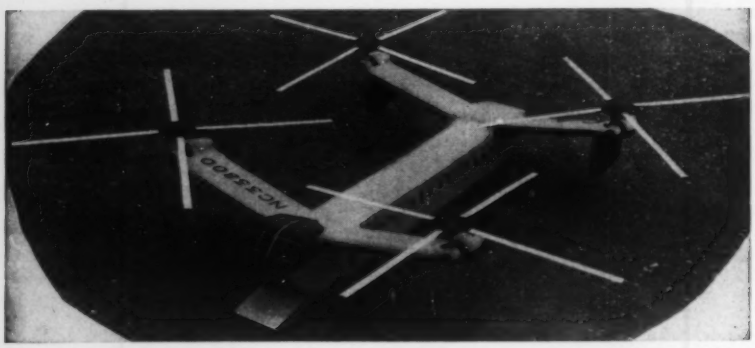
BOUND BROOK OIL-LESS BEARING CO., BOUND BROOK, N. J. EST. 1883



Quadrotor prototype developed by Convertawings Inc. claimed to simplify a number of design problems common to helicopters. Handling qualities are said to compare favorably with a stable airplane.



Application of quadrotor concept to a large flying crane which can be easily disassembled for transport. Single rotor design with same lifting power would require large blades subject to severe stress and fatigue problems.



Proposed passenger-cargo quadrotor with payload of 10,900 lb, max forward speed of 150 knots, range 300 mi. Airfoil sections increase stability, permit operation at lower blade pitch during forward flight.

Four-Rotor Helicopter Is Claimed Easier, Safer to Fly

Weight Efficiency Cited Over Single-Rotor Design

AMITYVILLE, N. Y.—Research toward development of four-rotor helicopters is subject of a recent contract awarded by the Air Force to Convertawings Inc.

According to the company, the quadrotor configuration offers a number of basic improvements over single rotor designs. Higher rotor rpm is possible, reducing blade weight substantially. Safer, better control is achieved by changes in thrust between rotors. Cyclic pitch control is thus eliminated and the complexity of hub and blade retention mechanisms is radically simplified.

The four-rotor design provides for multiple pod-mounted powerplants and auxiliary airfoils without adding structure. The identical blades are only one-half as long as on an equivalent single-rotor. Blade droop is greatly reduced with a corresponding reduction in necessary height and ground handling problems. The fuselage will be free of powerplants, improving safety and allowing flexible use of its full volume.

Research for Fusion Power Pushed by Private Industry

Controlled Fusion May Spur Direct Atom-Power Conversion

DALLAS, TEX.—Research aimed at producing electrical power through controlled thermonuclear reaction will be undertaken by private industry. A $10-million, 4-year program has been organized by the Texas Atomic Energy Research Foundation—a group of 11 southwestern utilities—and General Dynamics Corp.

A similar program was announced recently by the AEC. The Commission will build an experimental device at Princeton Univ.

Several outstanding advantages of a fusion process over present fission reactors are noted. AEC

alone

THE RHYTHM OF PRODUCTION

graphically depicting

AUTOMATIC MASS PRODUCTION TECHNIQUES

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It presents techniques of mass production which are completely changing present concepts of manufacturing.

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. . . will guide manufacturing techniques to unbelievable productive results,

. . . point the road to a better way of life, far in advance of current thinking.

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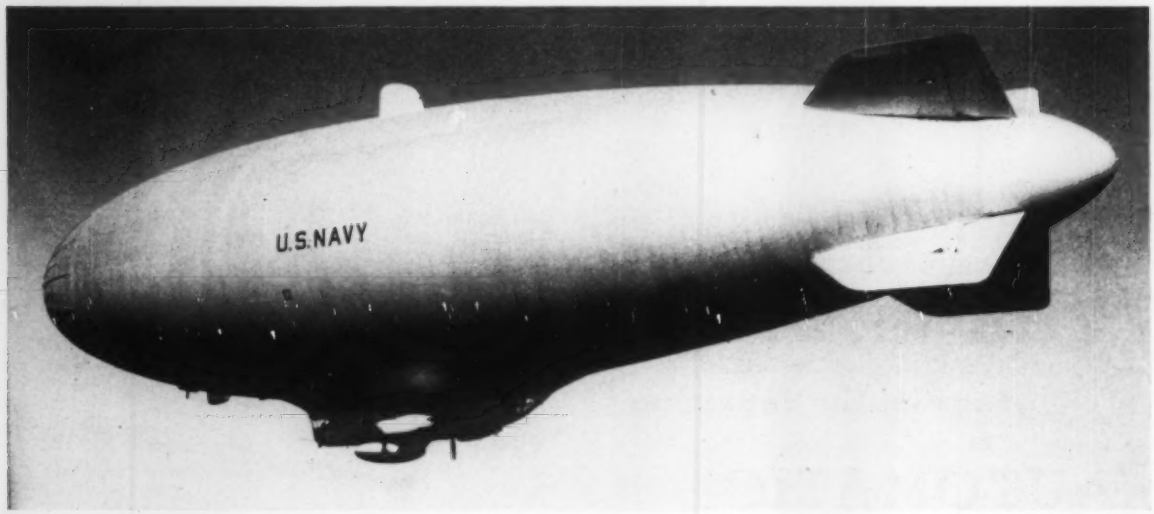


LARGEST RADAR ANTENNA ever flown by an aircraft revolves in the envelope of this radar picket blimp. Ship was developed for the Air Defense Command by Goodyear Aircraft Co. Blimps of the ZP6 class recently maintained a radar post 200 miles off the Eastern Seaboard for 10 successive days in a period of the worst weather recorded in 75 years. World's record of over 11 days continuous flight without refueling was established in covering distance of 9546 miles.

Almost any airfield is adequate for blimp landings and takeoffs through use of simple, portable mooring mast. Inherent low factor of "wear and tear" for engines, airframes and equipment eliminates complex maintenance problems common to heavy aircraft.

Chairman Lewis Strauss pointed out that 1 kg of deuterium, readily available in the sea, would produce about 100 million kwh of electricity. By comparison, the total output of all U. S. utilities last year was approximately 601 million kwh. Controlled fusion reaction does not produce large quantities of radioactive waste materials. This disposal problem is common to present reactors.

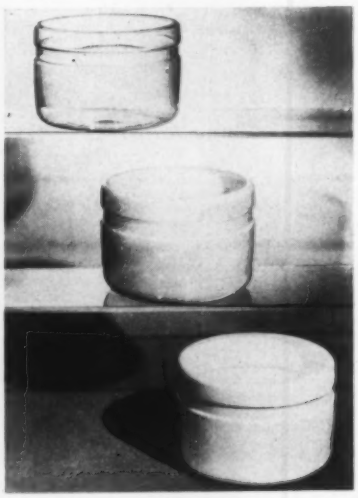
Many scientists believe that once the problems of controlled fusion are solved, direct conversion of nuclear energy into electrical power would be the next logical step. Conventional boilers, heat exchangers and generators would be eliminated.

Both the Texas group and the AEC, however, aim first to demonstrate controlled thermonuclear energy conditions. The research phase does not include an atomic generating plant.

The program gives further evidence of the determination of the private power industry to develop peaceful uses of atomic energy with private funds. It also demonstrates willingness of the AEC to act in advisory capacity.

New Ceramic Materials Have Combinations Of Properties That Rival Metals, Alloys

Corning's Pyroceram is family of new materials harder than steel, heat stable, light weight, transparent, cloudy or opaque.

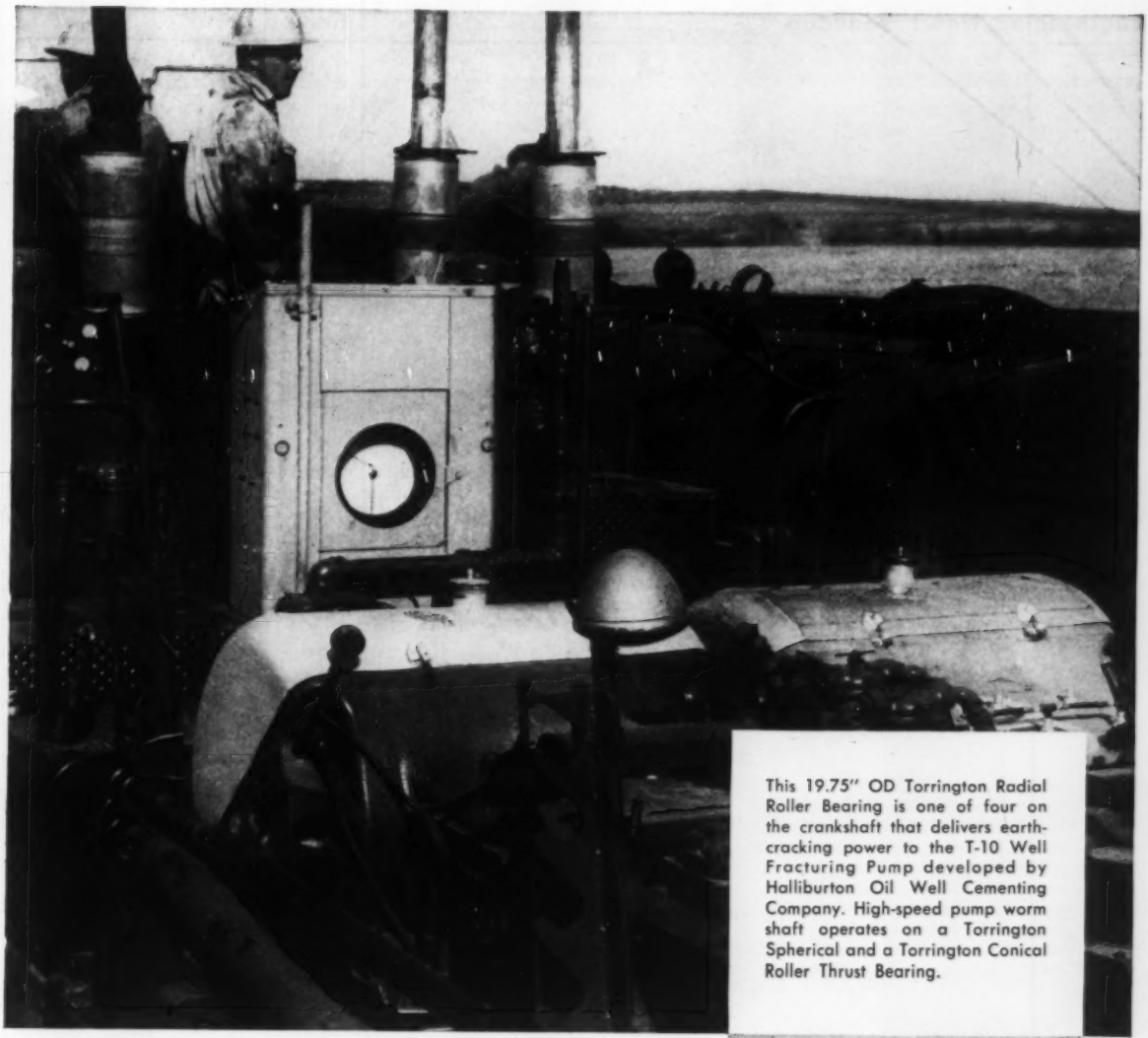


All three of these containers are made of Pyroceram. In final crystalline form, one Pyroceram remains transparent, another is translucent, another is white opaque.

CORNING, N. Y.—Unusual combinations of properties are featured in a new family of basic engineering materials recently announced by Corning Glass Works. Called Pyroceram, the new group is derived from glass but exhibits properties significantly different from those of glass.

Development of Pyroceram is credited to Dr. S. Donald Stookey of Corning's research and development division. The first Pyroceram is considered comparable in significance to the first steel.

Common characteristics of Pyroceram materials are high mechanical strength, excellent electrical insulating properties, high deformation temperatures, good thermal shock resistance and extreme hardness. Pyroceram types may be harder than high carbon steel, lighter than aluminum, and up to



This 19.75" OD Torrington Radial Roller Bearing is one of four on the crankshaft that delivers earth-cracking power to the T-10 Well Fracturing Pump developed by Halliburton Oil Well Cementing Company. High-speed pump worm shaft operates on a Torrington Spherical and a Torrington Conical Roller Thrust Bearing.

Controlling a man-made earthquake!

Millions of barrels of oil are being added to our recoverable resources by "fracturing"—a controlled, man-made earthquake. Sand-carrying fluid is pumped into a well with enough pressure to crack and enter a formation. Sand remains to prop open the new fissures.

Pressure is applied through a Halliburton T-10 Well Fracturing Pump. Mounted on the crankshaft of this pump are four Torrington Radial Roller Bearings. There they render dependable service and meet the demanding requirements of severe space and weight limitations.

The precision construction, quality steels and skilled heat treatment that go into Torrington Bearings have made them rugged, dependable performers in all types of oil-field equipment. Call on your Torrington representative for engineering service in the application of anti-friction bearings to your heavy-duty equipment. **The Torrington Company, South Bend 21, Ind.—and Torrington, Conn.**

TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • NEEDLE • BALL • NEEDLE ROLLERS • THRUST

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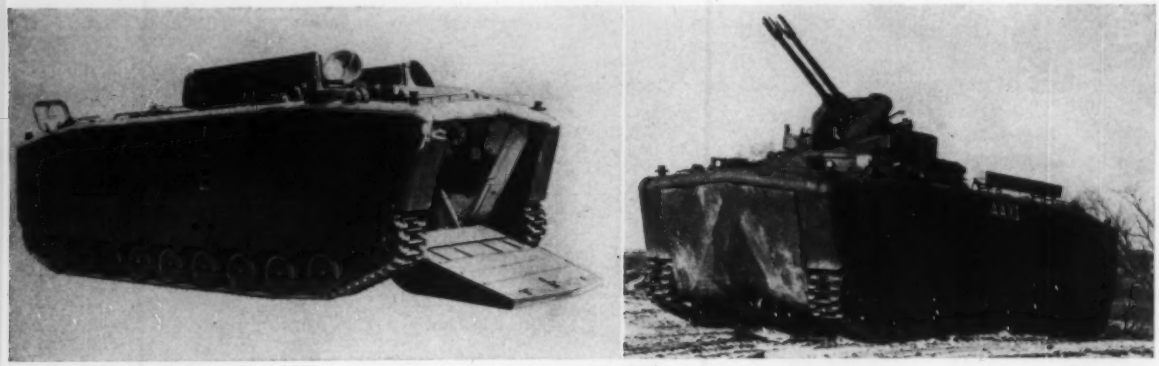
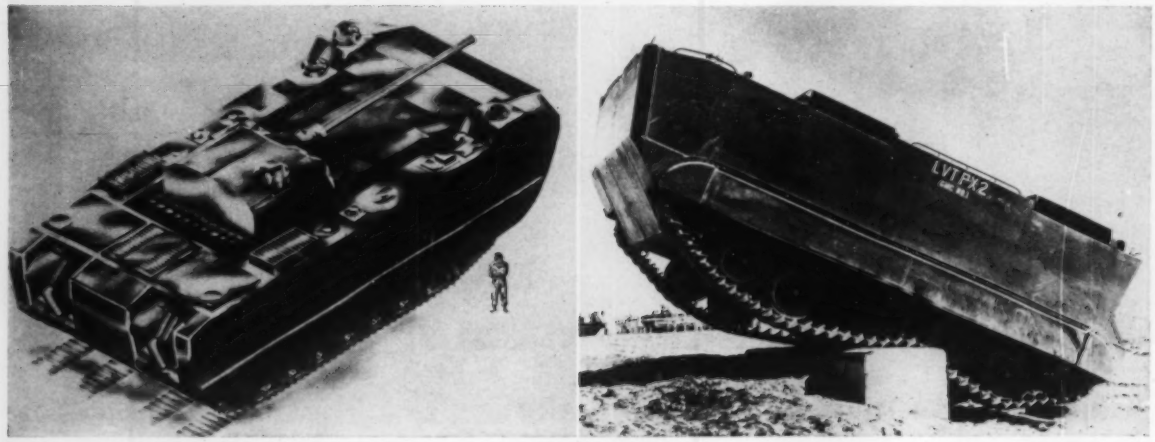


FAMILY RESEMBLANCE is characteristic of amphibious landing vehicles developed by the Navy Bureau of Ships for the Marine Corps. Although look-alikes, models differ in size, weight, capacity and performance. Need for assorted, fully enclosed equipment was result of Korean conflict. Basic vehicle is LVTP-5 (above, left). It weighs 70,000 lb, carries 18,000 lb on land, 12,000 lb in water, or 34 men. It is 29 ft long, 11¾ ft wide, 9 ft high. Speed on land is 30 mph; in water 7 mph. It negotiates a 70 per cent grade and an 8½-ft surf. Adaptations include 40-mm antiaircraft version (above, right). Smaller family member is LVTP-6 (below, right). It weighs 41,000 lb; is cheaper, more maneuverable than LVTP-5; carries 20 marines. Big brother in amphibious family is 60-ton LVTU-X-2 bulk cargo carrier. Below, left, is self-propelled gun version.



nine times as strong as ordinary plate glass.

Pyroceram materials differ from glass in that they are essentially crystalline in nature and they differ from ceramics in that their crystal structure is much finer. Crystals of Pyroceram may vary in size from a few hundred to a few thousand Angstrom units.

Unique in their method of manufacture, Pyroceram materials begin as glass melt and are worked by conventional glass methods. Products thus formed are then subjected to a heat treatment which causes a precipitation of tiny crystals throughout the body.

Missile radomes made from Pyroceram, before and after heat treatment that induces crystal growth; turns material from transparent noncrystalline into opaque crystalline.

The crystals may be limited to submicroscopic size or may be grown to sizes of one micron or more. Corning has developed methods of controlling the growth and chemical composition of these crystallites so that different types of Pyroceram may have physical properties tailored to specific requirements.

Pyroceram materials are low in density, below aluminum, and may be made with greater hardness than glass. One Pyroceram is three to four times as hard as type 302 stainless steel. By the nature of their manufacture, Pyroceram materials are nonporous and as im-

permeable to gases as the best glasses. This enables them to be used for high-vacuum apparatus.

Some types of Pyroceram can be made transparent in final form. Others can be made with a wide range of appearance from clear, through stages of diffusion or smokiness, to opaque, white products.

Thermal expansion coefficients of Pyrocerams may range from slightly negative to 200 × 10^{-7} per degree C. On the same scale, a Pyrex-brand glass is 32 × 10^{-7} and steel is 128 × 10^{-7}. Low thermal expansion and high tensile strength make Pyroceram type 8607 highly resistant to thermal shock. Another Pyroceram may be coated with a transparent semiconductor and transformed into an electrical heater.

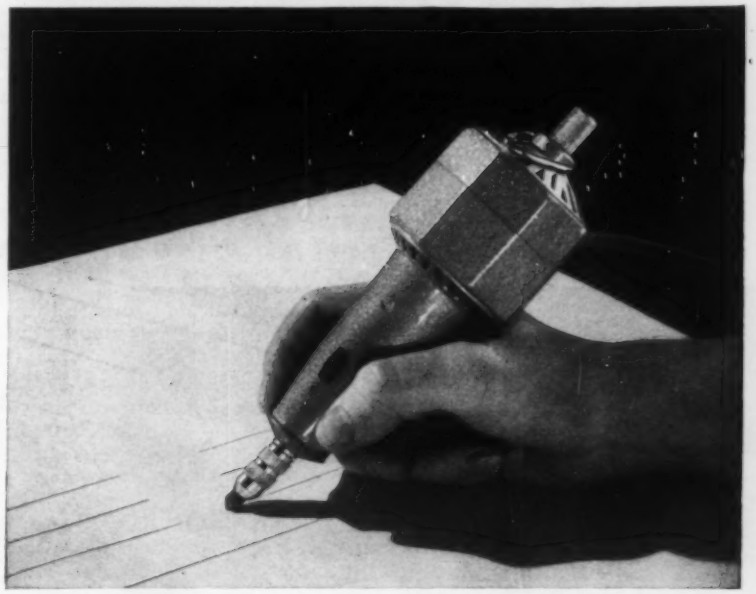
Crystalline Pyroceram can be made with very good electrical properties, particularly in the field of dielectric loss, even at red heat.

One Pyroceram has a flexural

(*Continued on Page* 22)

ACCURACY TO ONE PART IN A MILLION, or one second in 12 days makes this electronic chronometer a valuable aid to navigation. Power for the precision time and frequency standard is provided by a tuning fork oscillator. Output of the oscillator is amplified to drive a 60-pole variable reluctance synchronous motor. Besides time indication, time outputs—seconds, minutes, hours—are indicated by the closing of contacts. Four frequency outputs are maintained in multiples of 10 cycles up to 1000 cycles per second. All generated frequencies are accurate to 10^{-6}. Time Facsimile Corp., designers, requires 2 to 9 months to properly adjust tuning fork in each unit.

DRAFTING TRENDS



New erasing machine for fast, clean, effortless erasures

The idea of erasing machines certainly is not new. However, it wasn't until the Sovereign was developed that so many time-saving and drafting efficiency features were combined into one product.

Distributed by POST, the smooth-running, light weight Sovereign erasing machine can be used as accurately and effortlessly as a pencil point. Even for fine lines, just a dab with an easy-to-handle Sovereign gives a clean, neat erasure without damage to the drawing.

The speed of the rapidly rotating eraser does the work, not pressure. In fact, if too much pressure is used, the machine automatically stalls, thereby safeguarding your drawing. Operation is cool, as the Sovereign definitely will not overheat.

Using a Sovereign is just as easy as reaching for an old fashioned eraser . . . and much more convenient. Curved to fit the hand, it incorporates many design features of special appeal to engineers and draftsmen. For example, the hollow armature shaft takes a full 7″ core eraser which feeds through an instantly adjustable chuck. The extra long eraser eliminates those frequent, annoying changes often associated with ordinary erasing machines using short erasers. (When a change is finally made, the chuck cuts replacement time to *less than 10 seconds.*)

The large loop hanger is ideal for hanging the Sovereign within easy reach of the board. Or, if the erasing machine is used frequently, the octagonal shape design permits the draftsman to lay it on the drawing board without fear of it rolling off.

For more information on the Sovereign Erasing Machine, see your POST dealer or write to the Reader Service Division of the Frederick Post Company, 3652 N. Avondale Ave., Chicago 18, Illinois.

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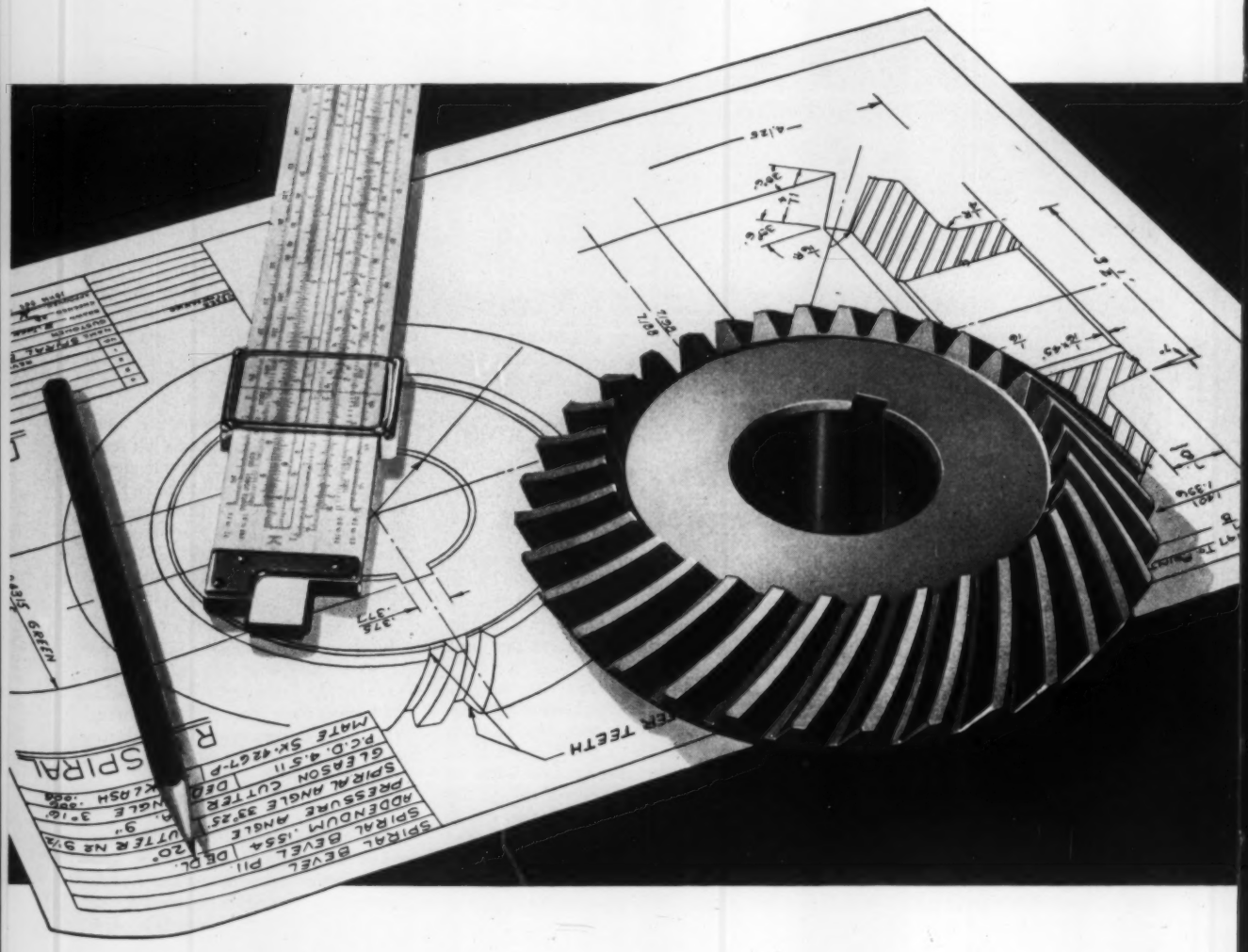
Circle 410 on page 19

"ENGINEERED QUOTATIONS"

When our engineers study our customers' prints, they look for ways to improve gear performance, ways to simplify gear installations, ways to cut gear costs. When they find a way that they consider better they report it to the customer for his consideration. Very often these "engineered quotations" are accepted. Such careful scrutiny of every engineering and manufacturing step by *gear specialists* is one reason why so many manufacturers use Automotive Gear Division as their "gear department". May we submit an "engineered quotation" on your gear requirements?



EATON

AUTOMOTIVE GEAR DIVISION
MANUFACTURING COMPANY
RICHMOND, INDIANA

GEARS FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS

Circle 411 on page 19

Reader Information Service

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CIRCLE ITEM NUMBERS—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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420	445	470	495	520	545	570	595	620	645	670	695	720	745	770
421	446	471	496	521	546	571	596	621	646	671	696	721	746	771
422	447	472	497	522	547	572	597	622	647	672	697	722	747	772
423	448	473	498	523	548	573	598	623	648	673	698	723	748	773
424	449	474	499	524	549	574	599	624	649	674	699	724	749	774
425	450	475	500	525	550	575	600	625	650	675	700	725	750	775

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Page No. Title of Article

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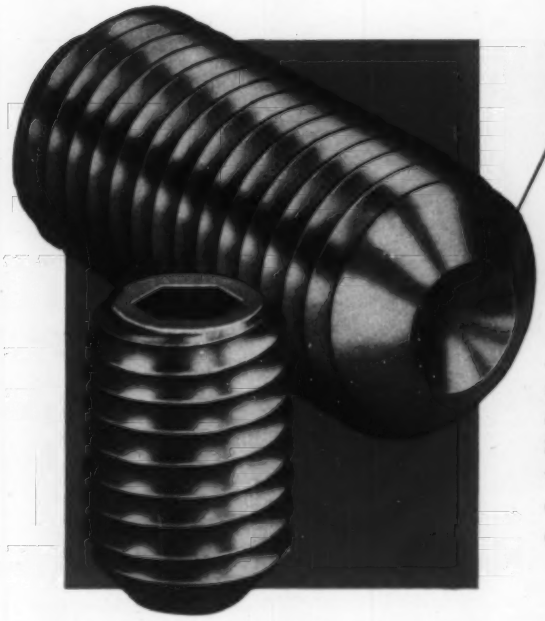


ALLENPOINT will give you a bulldog grip at no premium in price!

Allen's scientific redesign of the cup diameter on set screws gives greatly increased resistance to *withdrawal* torque. You can count on Allenpoint Set Screws to stay tighter longer, under heavy strain and vibrations. This dependable premium performance of Allenpoints is yours to use without increasing the cost of manufacturing your products.

Uniform Class 3A Threads

Allenpoints' smooth, uniform threads prevent off-lead conditions like Fig. 1. With Allenpoints, you have full, even contact between the engaging flanks of the threaded members (Fig. 2) —and a tight friction lock over the entire length of the Allenpoint Set Screw.

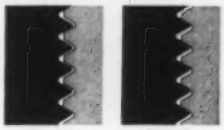


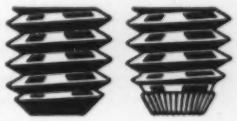
Fig. 1 Fig. 2

Strong, clean, deep sockets allow full wrenching leverage

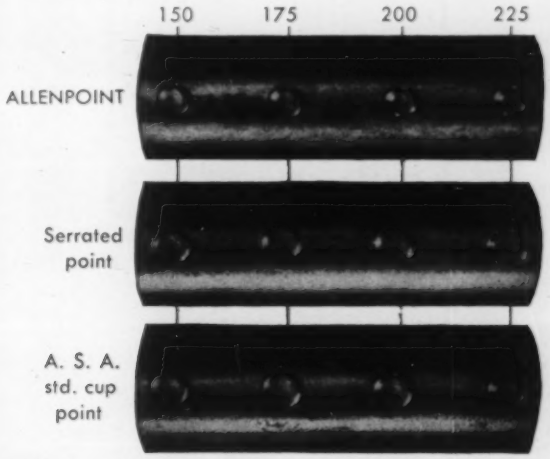
Sockets of Allenpoint Set Screws are cold forged to produce a deeper, smoother socket. No broach chips to interfere with proper seating of the key. This "pressur-forming" preserves the long steel fibers throughout the length of the screw—stronger walls allow maximum tightening torque.

One more full thread on ALLENPOINTS!

Allenpoint Set Screws have one more full thread than serrated point set screws. That means more holding power—especially important when you're using short lengths.



ALLENPOINT's performance compared for you



These actual-size, unretouched photographs show the cup pattern made by Allenpoints, serrated points, and A.S.A. standard cup point set screws in a 3/4" steel shaft. At each degree of tightening force, Allenpoints make a full circle pattern, penetrating deeper for greater holding power.

We'll be glad to send you more information and samples of Allenpoint Set Screws and other Allen Socket Screw products.

Stocked and sold by leading industrial distributors everywhere

ALLEN MANUFACTURING COMPANY
Hartford 2, Connecticut, U.S.A.

ALLEN HEX-SOCKET SCREWS HEAD

(*Continued from Page* 15)
strength of 37,000 psi compared to 20,000 for steatite and 5000 for window glass. The elasticity of some types of Pyroceram is nearly twice that of average glass; 2/3 that of steel. Pyrocerams maintain this strength up to 1380 F.

Pyrocerams can be formed by present techniques for glass, but the first Pyroceram product was formed by centrifugal casting. This was the first homogeneous, all-crystalline radome for guided missiles.

American Gear Manufacturers Association announces election of officers at its recent 41st Annual Meeting. President for the coming year is LeRoy R. Brooks, president of Tool Steel Gear & Pinion Co., Cincinnati, O.; vice president, E. F. Borisch, executive vice president of Milwaukee Gear Co., Milwaukee; treasurer, John L. Buehler, president of Indiana Gear Works Inc., Indianapolis.

DO-IT-YOURSELF REACTOR, called Argonaut, is this low-power, low-cost reactor developed for use by students attending the Argonne National Laboratory's International School of Nuclear Science and Engineering. Safety features make it especially useful for training purposes. Self-sustaining chain reactions can be achieved with different fuel shapes. Response to control rod operation and high-power operating conditions can be studied. The reactor will also be used for nondestructive chemical analysis and radiation instrument calibration.

MECHANICAL MINE PLANTER, one-man-operated, will lay antitank minefields in a fraction of the time required to do the job manually. The new vehicle was developed jointly by the Army Engineer Research and Development Laboratories and International Harvester Co. Mines to be planted are carried in a "lazy Susan" type magazine atop the four-wheel trailer. At the rear, a large side-elevating plow opens a trench to receive the mines, and a mechanism automatically arms the mines and drops them into the trench. The plow is designed to lift the soil on its side, then drop it back into place as mines are planted. In operation, planter can be pulled by any large crawler tractor. On highways, the planter can be towed by a standard military truck at regular transport speeds.

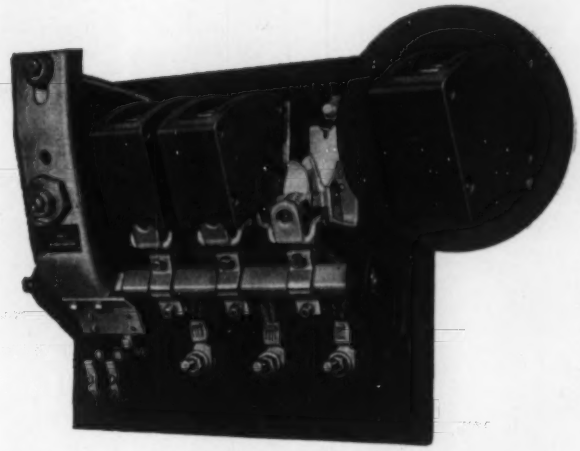
New Techniques, Products Offered Industry by AEC

Small Cost Involved for Volume of Atomic Data

OAK RIDGE, TENN.—An extensive source of new techniques and products is provided through a program recently completed by the Atomic Energy Commission. The new program "will save industry thousands of dollars in engineering work," according to Melvin Day, chief of the AEC's technical information service.

Volumes of atomic energy data in the form of documents, blueprints, and confidential memoranda have been declassified and processed for release. Information that can be practically applied to industry is included. Centralized facilities for editing, printing and cataloging material, and for handling inquiries, have been established at Oak Ridge by the technical information service. From this centralized agency, catalogs of drawings, photographs and specifications on a wide range of materials and equipment are now ready

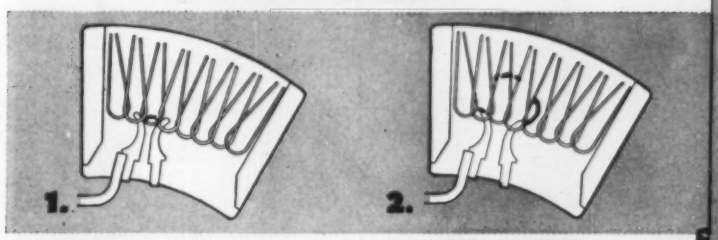
for fast arc interruption... without blowout coils



ALLIS-CHALMERS TYPE 425 CONTROL

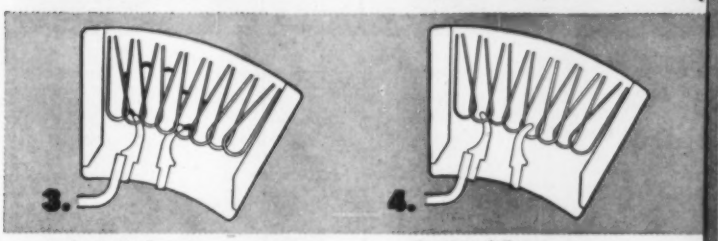
featuring *ACBO* arc-centering blowout chutes for 50 to 400 hp

The advanced electrical design of Allis-Chalmers Size 4, 5 and 6 control incorporates a modern principle of arc interruption for low voltage, high horsepower applications. The *ACBO* arc chute utilizes principles of magnetic action and thermal convection to center, rupture and extinguish the arc . . . quickly. Fast arc interruption assures maximum contactor efficiency, improves performance — greatly prolongs contact and chute life.



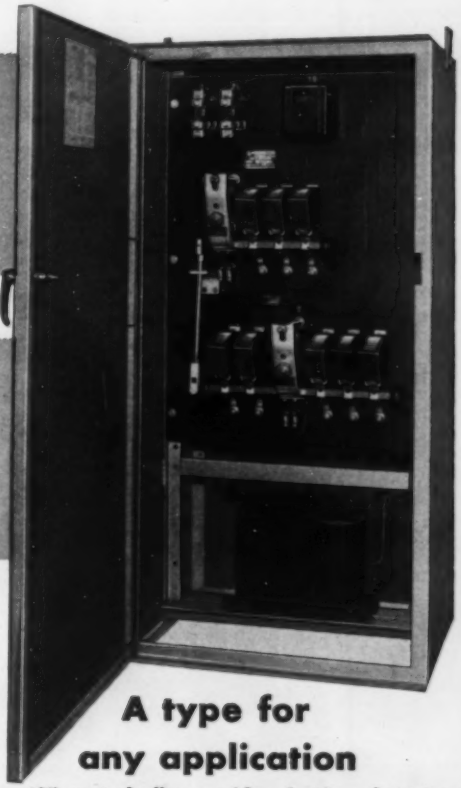
Arc across contacts as they start to open.

Strong blowout action forces arc to center.



Arc rupturing.

Contacts fully open—arc extinguished.



Simplified mechanical design

- Streamlined clapper-type construction eliminates many parts.
- Accessibility simplifies maintenance and inspection.
- Installation is fast and easy . . . sensible enclosure dimensions provide ample wiring space.

A type for any application

Type 425 control offers a wide selection of starters and contactors for any application. For detailed information, call your A-C Control Distributor or your local A-C District Office . . . or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin. Ask for Bulletin 14B8615.

A-C ALLIS-CHALMERS

ACBO is an Allis-Chalmers trademark.

A-5343

ALLIS-CHALMERS

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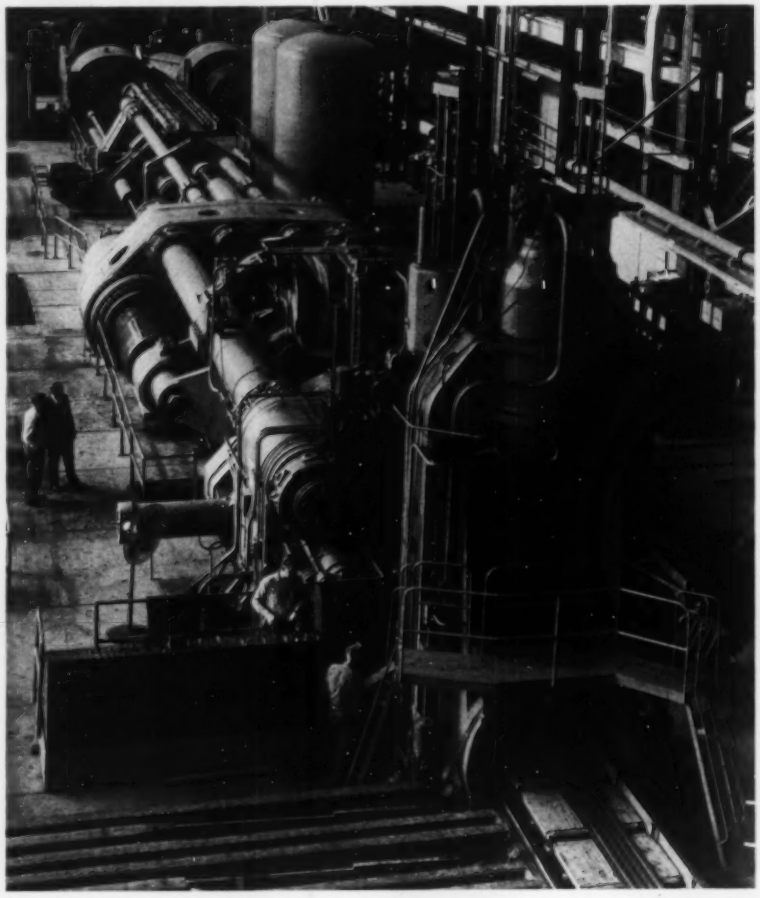
for efficient distribution. One AEC source estimated that over 50 million pages of material on atomic energy are available to any interested parties.

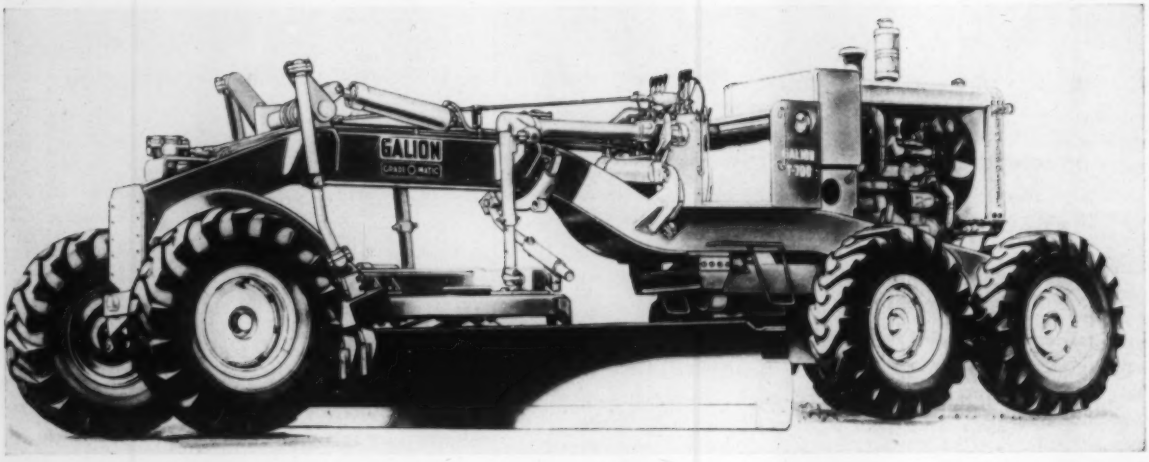
The information service has also made available semimonthly journals containing abstracts of atomic papers. Any pertinent information released by colleges, private organizations and other sources will be noted in the journals.

Companies lacking facilities for informational research will be able to employ AEC researchers. For $6 an hour, these researchers will track down every publication concerning questions submitted.

The AEC, working with the American Library Assoc., plans to expand its depository library program. The intention is to locate a library of atomic information in at least every city with a population of 500,000 or more.



LARGEST MAGNESIUM EXTRUSION PRESS is claimed to be this German designed model at Dow Chemical Co. For U.S. aircraft components, it produces extrusions as long as 80 ft; larger in cross sectional area than previously available.



WORLD'S LARGEST, HEAVIEST MOTOR GRADER is said to be this 20-ton model in production by Galion Iron Works Co. Despite size, unusual ease of operation is achieved through power-shift transmission. Fingertip control levers select up to three speeds forward, three reverse. Torque converter adjusts speed of 190-hp diesel engine to meet any loads and conditions. Hydraulic shiftable mold board is 14 ft long, 30 in. high, 1 in. thick. Tires are 16.00 x 24. Other features include four-wheel hydraulic service brakes, foot decelerator for quickly reducing engine speeds without changing hand throttle and a transmission brake for parking.

Missile Muster

Summaries of guided missiles developed by the three armed services have been announced by the Dept. of Defense. Principal characteristics and capabilities of these weapons are listed here. Starred items (*) are operational.

Army

Name	Employment
Nike-Ajax*	Surface-to-air
Corporal*	Surface-to-surface
Redstone	Surface-to-surface
Jupiter	Surface-to-surface
Lacrosse	Surface-to-surface
Dart	Surface-to-surface
Nike-Hercules	Surface-to-air

Nike-Ajax is about 20 ft long, 1 ft in diameter. It has two sets of fins for guidance and steering. It is boosted to supersonic velocity by a solid propellant and its speed is maintained by a liquid fuel motor.

Corporal can be equipped with either an atomic or conventional warhead. It can engage tactical targets at ranges over 75 miles.

Corporal uses a liquid propellent rocket motor and travels several times the speed of sound.

Redstone is the largest surface-to-surface ballistic guided missile successfully fired in the U.S. It will supplement conventional artillery and can deliver atomic or nonatomic explosives.

Jupiter, derived from Redstone, is the Army's intermediate-range ballistic missile.

Lacrosse is a highly accurate field artillery missile for close tactical support of ground troops.

Dart is an antitank missile powered by a solid-propellant rocket. It is intended for the use of front-line troops and it carries a warhead capable of defeating the heaviest known enemy armor.

Nike-Hercules will be the Army's second land-based missile to be placed in the U.S. air defense system. It can travel higher and farther than Nike-Ajax to engage formations of aircraft or single planes. The missile alone is 27 ft long; the booster, 14.5 ft.

Navy

Name	Employment
Sidewinder*	Air-to-air
Petrel*	Air-to-surface
Regulus*	Surface-to-surface
Terrier*	Surface-to-air
Sparrow I*	Air-to-air
Sparrow II	Air-to-air
Sparrow III	Air-to-air
Talos	Surface-to-air
Tartar	Surface-to-air
Polaris	Surface-to-surface

Sidewinder is basically a defensive weapon intended for operation against high-performance aircraft. Its feature is simplicity. It has no more electronic components than an ordinary radio.

Petrel is intended for use against ships at sea. It is carried and launched by patrol aircraft and fleet squadrons.

Regulus, 30 ft long, resembles a swept-wing fighter plane. Versatile launching equipment enables it to operate from submarines, surface ships and shore bases. Regulus II, under development, will fly farther and faster than its predecessor.

Terrier is the main antiaircraft weapon of the cruisers *Boston* and *Canberra* and the destroyer *Gyatt*. It will be used on future destroyer-frigate-type vessels. Terrier is designed to intercept aircraft at longer ranges and higher altitudes than conventional antiaircraft guns, under all weather conditions.

Sparrow I is 12 ft long, weighs 300 lb, powered by a solid-propellant rocket motor. Guidance signals deflect its wings, direct it to target even under evasive action. **Sparrows II** and **III** are improvements.

Talos is larger than Terrier, has greater range. It will be installed on the cruisers *Little Rock, Galveston* and *Oklahoma City*.

Tartar is a solid-propellant weapon, cheaper than Terrier, will go on new guided missile destroyers

Statham liquid rotor angular accelerometers are rugged and reliable. They may be ordered with either an unbonded strain gage or inductive pickoff and are available in ranges from ±1.5 to ±3,000 rad/sec².

Please request our Accelerometer Catalog and Instrument Notes No. 26 "Some Design Considerations For Liquid Rotor Angular Accelerometers"

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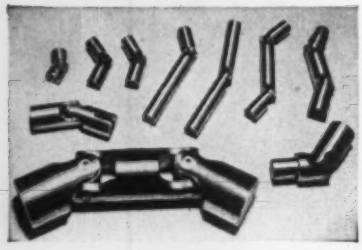
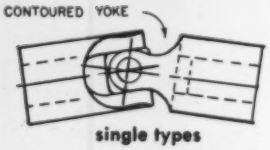
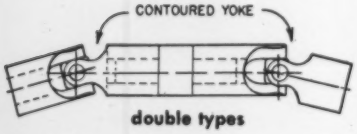




single types



double types

Check these features against your requirements:

Special Contoured Yoke—capable of operating at a maximum angular misalignment of 45° on hand-operated applications.

Static Torque—from 306 to 129,693 in.-lbs. at 12°, depending on size of joint.

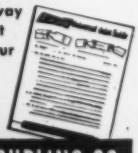
Horsepower Ratings—.54 to 207 at 100 rpm.

Tolerances—pins ground to .0005" ... forks concentric to within .001" ... precision accurate center blocks.

Standard Specifications—hub diameters ½ to 4" ... bores ¼ to 2" ... lengths (single) 2 to 10⅝", (double) 4 to 21¼". All specifications can be altered or special joints designed to individual requirements.

Get this handy guide

It's the quick and easy way to get the Universal Joint that is just right for your application. Request Bulletin 820.



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Circle 415 on page 19

Missile Muster, Cont'd.

and on larger ships as secondary armament.

Polaris is the Navy's Intermediate Range Ballistic Missile, a counterpart to Jupiter, with special ship-launching provisions.

Air Force

Name	Employment
Matador*	Surface-to-surface
Falcon*	Air-to-air
Snark	Surface-to-surface
Navaho	Surface-to-surface
Rascal	Air-to-surface
Bomarc	Surface-to-air
Atlas ICBM	Surface-to-surface
Titan ICBM	Surface-to-surface
Thor IRBM	Surface-to-surface

Matador is 39.6 ft long, has 28.7-ft wingspan, is ground-launched, attains 650 mph and 35,000-ft altitude. Powered by Allison jet engine, it has several hundred mile range. Improved Matador TM-61C will have greater range, better guidance.

Falcon, 6 ft long, weighs 100 lb, is powered by solid rocket propellant. It is carried in quantity underwing or in pods, electronically fired and guided.

Snark is the first U.S. long-range missile to be test flown. Range in these tests was about 3000 miles.

Navaho is a rocket-launched, air-breathing missile said to have range, accuracy and load-carrying capacity as good as ballistic types.

Rascal is a rocket-powered pilotless bomber to be carried near targets by piloted planes.

Bomarc is launched vertically, cruises on twin ram-jet engines. Its range enables it to destroy aircraft at a greater range than any other missile in the Air Defense Command.

Atlas and **Titan** are Intercontinental Ballastic Missiles and **Thor** is an Intermediate Range Ballistic Missile. Prime contracts have been negotiated and extensive interchangeability of elements should speed completion.

New Economy Car Series Introduced by Studebaker

SOUTH BEND, IND.—The Champion Scotsman, Studebaker's new entry in the economy car field, is offered in three body styles—two and four-door sedans and a two-door, six-passenger station wagon.

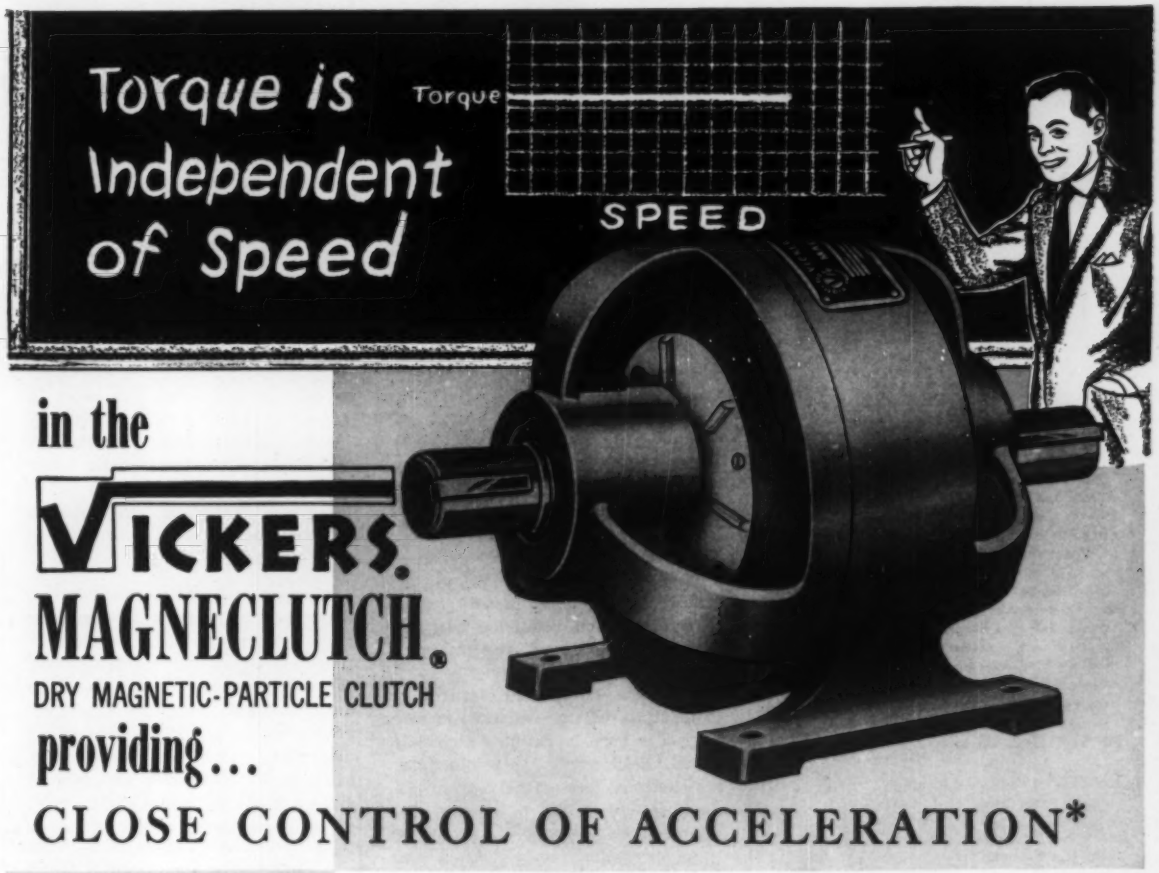
All models are powered by a 101-hp, six-cylinder engine designed to give up to 29 miles per gallon. A three-speed manual shift transmis-

Engine Specifications

Type	L-head, In line
No. cyls.	6
Bore and stroke (in.)	3 x 4.38
Displ. (cu in.)	185.4
Comp. ratio	7.8 to 1
Bhp, max	101
Torque, max (lb-ft)	152

	Sedan	Station Wagon
Wheelbase (in.)	116.5	116.5
Length (in.)	202.4	202.4
Width (in.)	59.8	61.7
Height (in.)	75.8	75.8

Studebaker Champion Scotsman four-door sedan, one of three models available in one of three colors, features simplicity; consequent low price.

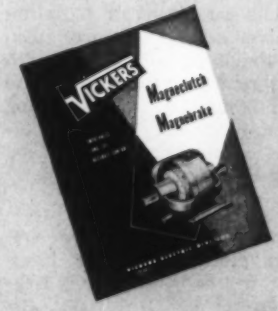


in the VICKERS® MAGNECLUTCH®

DRY MAGNETIC-PARTICLE CLUTCH

providing...

CLOSE CONTROL OF ACCELERATION*



Vickers MAGNECLUTCH may also be used for braking and tension control. Get the complete facts. Write today for bulletin and application data forms.

IN the Vickers MAGNECLUTCH, torque is transmitted through the linking action of magnetized ferromagnetic particles in the gap between driving and driven members. The amount of torque transmitted is regulated by varying the amount of energizing current, and is independent of the rotational speed of the driving and driven members. This torque transmission principle permits extremely close control of acceleration.

VICKERS MAGNECLUTCH

Also Offers These Other Outstanding Advantages

SMOOTH OPERATION
LONG LIFE, *because there's no wear on torque transmitting surfaces*
TORQUE AT ZERO SLIP—*torque transmitted with 100% mechanical efficiency*
EXTREMELY FAST RESPONSE
SMALL CONTROL POWER
EASILY ADAPTED TO REMOTE CONTROL

*Equally close control of deceleration may be obtained with Vickers MAGNEBRAKES.

VICKERS ELECTRIC DIVISION

VICKERS INCORPORATED a unit of Sperry Rand Corporation

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Circle 416 on page 19

sion, defroster and directional signals are standard equipment.

Optional equipment includes overdrive, electric windshield wipers, wet type air cleaner and a hideaway seat for the station wagon.

Automated Schoolroom Speeds Education

COVINGTON, LA.—Electronic communication between teacher and students has proven very success-

Computer Comments

Television-size computer, named Leprechaun, that requires less power to operate than a TV set has been developed by Bell Telephone Lab. for the Air Force. The device operates with about 9000 electrical components, considerably less than previous computers. Transistors account for more than half of its components. Simplified circuit arrangement is said to be easily explained, requiring less experienced personnel for maintenance.

The new computer features a transistor - driven, random - access magnetic core memory, which can store 1024 "words." It can take instructions immediately from its memory, resulting in almost instantaneous solution to problems it has to solve. This process differs from that of computers with a revolving drum memory, which may require time for rotation of the drum before instructions can be taken from their place.

• • •

Fastest general purpose digital computer ever designed will be acquired by the Navy's Bureau of Ships. More than 100,000 multiplications per second are possible with Univac-Lark, designed by Remington Rand. The computer will speed the solution of problems associated with nuclear reactor development for shipboard power plants.

A unique feature of Lark is the use of two separate computers to make one integral system. One computing unit performs the arithmetic needed. The second computer simultaneously controls the flow of data required by the first unit. This use of an "input-output processor" greatly expands the capacity and speed of the entire system.

Lark is divided mechanically and functionally into separate units. By the addition of different types of these units the capacity of the computer can be increased in a variety of ways. For example, a second arithmetic computing unit can be added. With this configuration, the two arithmetic units can co-operate to solve one problem more quickly, or two problems simultaneously.

• • •

Advantages of film and digital recordings have been combined in a new recording and reading system developed by the Magnovox Co. The system is applicable to any problem when a combined photographic and digital record is desirable. Cameras capable of making 32 exposures per second are available in 16 mm and 35 mm. Each exposure is a simultaneous view of the equipment under test and the related digitally coded data. At present camera speeds, 2880 bits per second of digital information can be recorded. System normally includes camera with digital recording head, analog to digital converter, film reading system, print and equipment for visual examination of data, and punched paper tape recorders.

• • •

High speed data reduction system to process test flight information will be built by Tally Register Co. for the U. S. Navy. The system will accept voltages from up to 40 different sources which have been electronically recorded during flight. It will take 50 samples per second on each of 40 inputs, or 2000 per second on any one, or any combination totaling 2000. Samples will be "memorized" and sequentially converted to digital form on magnetic tape for processing on a Burroughs Datatron Computer.

This type of system enables engineers to select only significant information for analysis and handling from tremendous volumes of data provided by automatic measuring devices.

HELP
for engineers!
STANPAT—the remarkable tri-acetate that is pre-printed with your standard and repetitive blueprint items, easily transferred to your tracings by an adhesive back or front. Relieves time-consuming and tedious detail of re-drawing and re-lettering specification and revision boxes, standard symbols, sub-assemblies, components and cross-sections. Saves hundreds of expensive hours of drafting time and money, frees the engineer for concentration on more creative work.
so simple to use:
① PEEL the tri-acetate adhesive from its backing.
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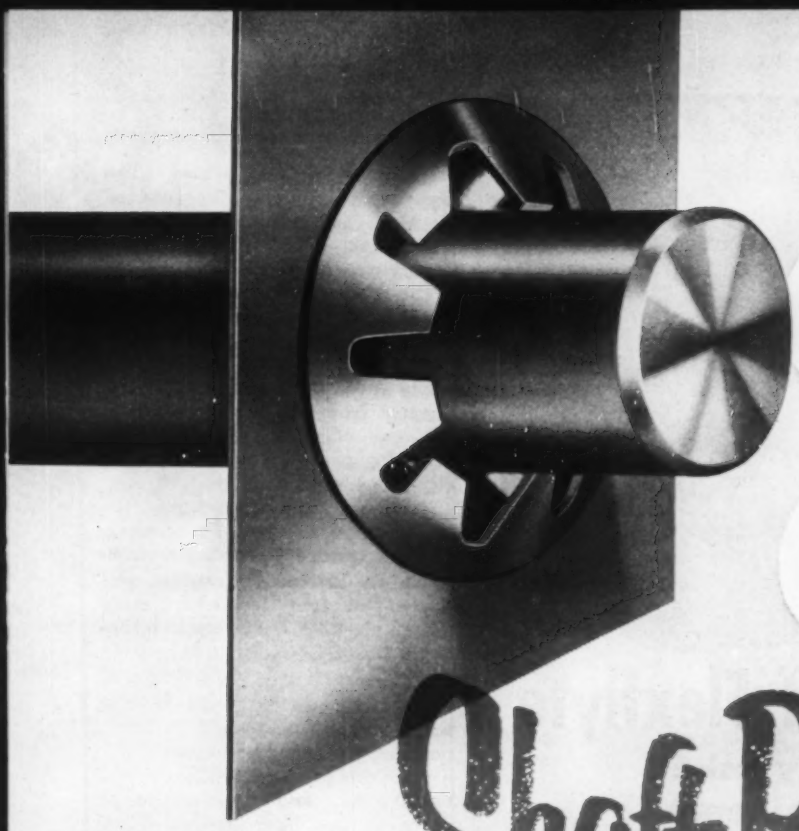
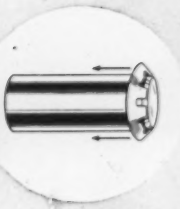




Pilot teeth guide fastener on for easy hand starting.

Hardened spring steel teeth bite in, resist dislodging force.

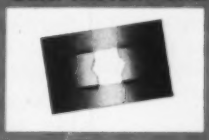
for positive Shaft Retention

FASTEX® SPRINGRIP FASTENERS

Simplify assembly, save costs! Springrip Fasteners are simple to apply to rods and studs . . . assure exceptional strength without special preparation . . . no costly threading or drilling required. Standard Springrip Fasteners with pilot teeth now in stock and available for immediate delivery. Full details on all cost-saving Springrip Fasteners and other Fastex Shaft Retention Fasteners are found in new Fastex Catalog No. AF-9. This important booklet contains complete technical data, dimensions and application suggestions. Write for your catalog today!

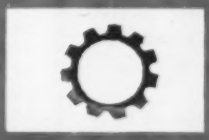
Other *FASTEX*® Shaft Retention Fasteners

FASTEX® Plasti-Ring® Retainers
Made of non-aging, chemical resistant vinyl . . . act as positive holding shoulder.



FASTEX® Push-On Fasteners
Slip over studs, shafts, rods or bolts . . . hold tight under pressure or vibration.

FASTEX® "C" Ring Retainers
The fast, simple method for retention or spacing on rods or shafts . . .



FASTEX® External-Tooth Springrip Fasteners
For use in tubes or bored holes . . . provide spring lock for positive retention.

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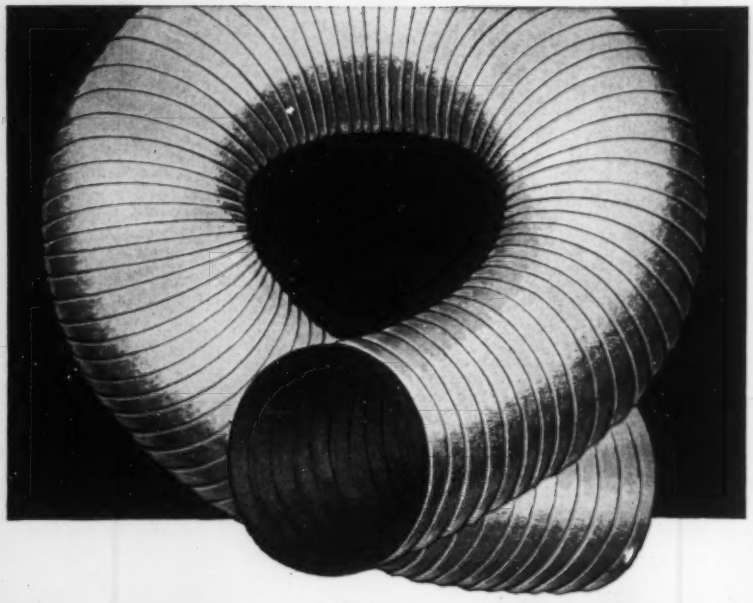


Questions about Flexflyte®

most frequently asked by design engineers

What is Flexflyte?
A lightweight, reinforced ducting made of a spring steel wire helix covered with coated fiber glass or a cotton fabric and bound with a fiber glass cord.

What are its applications?
Equipment designers will find Flexflyte ideal for applications where an unobstructed flow of air, gases, liquids, chemicals, light solids must be maintained.

How flexible is Flexflyte?
It will take tight turns at any point up to 180° without buckling. No elbows or fittings are required.

What are its temperature ranges?
From minus 120°F. to plus 650°F.

What pressures will Flexflyte handle?
Internal working pressures up to 70 psi and external working pressures up to 15 psig.

Is it flame resistant?
Flexflyte has exceptionally high flame resistance and will not support combustion.

What about Flexflyte's resistance to abrasion?
It is highly resistant to abrasion, especially when coated with FT-506 which has more than 200 times the abrasion resistance of any tubing of its type and weight.

What about installation?
Flexflyte is quickly, easily installed around corners and equipment parts by means of metal clamps. It is also available with special enlarging or reducing ends, either cylindrical, rectangular or polyhedral.

Can Flexflyte be engineered for unusual applications?
Yes. Special fabrics, coatings, connections, lengths and diameters are available. Our special Silicone Department, working with automated machinery, is prepared to meet any requirement for silicone ducting.

How can I make sure that Flexflyte will solve my problems?
Write us, outlining your requirements. Our engineers will be glad to put their experience to work for you. Write Dept. 186.

Flexible Tubing
CORPORATION
GUILFORD, CONNECTICUT • LOS ANGELES 64, CALIFORNIA

News Roundup

ful in an elementary school. The experiment, probably the first of its kind, has completed a year's trial at St. Scholastica Academy, Covington, La.

The teacher presides at an electronic console in the place of the old fashioned desk. Each seat in the classroom is provided with earpones wired to receive instruction directly from the teacher or from any one of four tape recorders. Students can be reached individually or on a group basis.

Through tape recordings the teacher can conduct four simultaneous lessons in a single classroom. Or instruction can be conducted on four levels, to more nearly meet differing requirements of individual students. Repetition for the benefit of a few students is eliminated, as recordings can be made and communicated to those needing further instruction.

Children in this school were said to have done two or more years of work in one year, measured by standardized tests. A Ford Foundation grant will enable further study of the method.

Government Advised To Restudy Its Engineers' Status And Pay

WASHINGTON, D. C.—Separate classification and pay schedule for engineers employed by the U.S. Government has been recommended to a Senate subcommittee in testimony by the National Society of Professional Engineers.

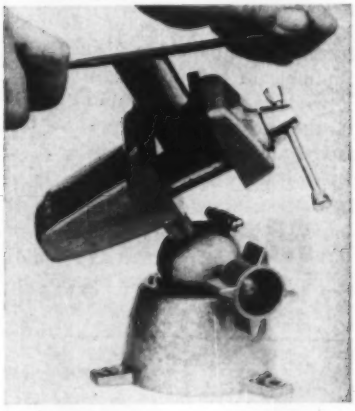
NSPE emphasized that "an adjustment of the salaries of engineers and scientists in the Federal service is in order and is required if the government is not to fall further behind in its effort to obtain and retain competent engineering staffs." An NSPE salary survey for 1956 indicated that engineers in the Federal service were paid at a rate 21 per cent lower than in private industry.

In addition to immediate or long-range salary increases, NSPE advocated that the Government afford professional recognition for its scientists and engineers. To assure that the engineers in Federal

Circle 419 on page 19

service are fully qualified for their positions by reason of education, training and experience, NSPE believes their competence should be certified by qualifying as professional engineers.

Approximately four years of broad and progressive professional engineering experience would be a requirement for new engineers and for employees promoted to engineering positions. The point at which registration as a professional engineer would be required would be a proposed classification SPS-5 ($8710—$9610).



VERSATILE VISE can replace jigs and fixtures for light assembly operations. Vise head can be removed, mounted on any plate or fixture with 5/8-in shaft. Made by Pacific Durable Products, unit has jaw width of 2½ in. opening of 2½ in., will swing 360° on any tangent to a half sphere.

Air Force Seeks 1200 F Bearings, Lubricants

WRIGHT-PATTERSON AFB, O. — Modes of failure for rolling-contact bearings operating at temperatures ranging from 300 F to 600 F, are subjects of a research program being done by Battelle Memorial Institute for the Air Force.

Increasing temperature demands on airframe bearings in high-speed aircraft and guided missiles have pushed bearing requirements beyond the range of current design information. "Data are practically

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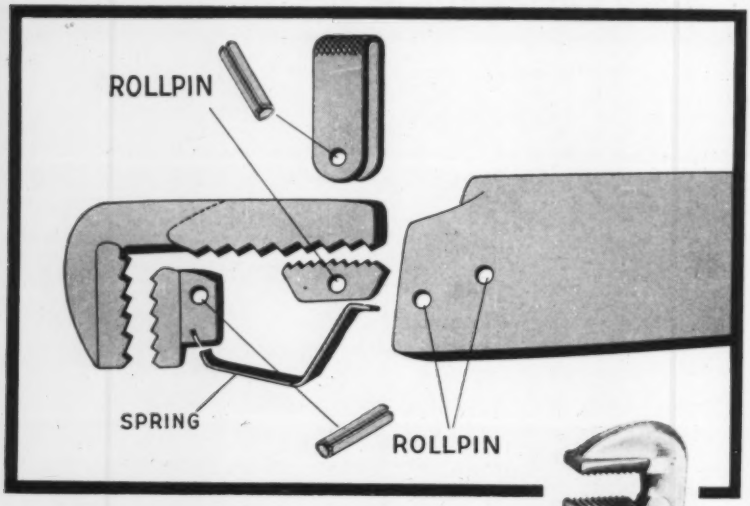
Circle 420 on page 19

FASTENER PROBLEM



Re-usable fastener solves parts replacement in automatic wrench

A new wrench design by H. R. Basford Company called the "Gripso-matic" offered a neater, quicker and lighter implement with "pushbutton," one-hand jaw adjustment. One of the assembly problems that required solution was a method of fastening several parts together so the head could be replaced in the event of broken or damaged parts. Rivets can't readily be removed and replaced. Nor can other standard fasteners once they get battered in service.

Rollpin was the final selection. It's the pressed fit spring pin, oversize in relation to standard production drilled holes, that locks itself into place by means of the constant pressure it exerts against hole walls. Removal is easy—Rollpin is simply driven out with a punch and, thanks to chamfered ends, it is readily hammered back in place upon re-assembly. In addition to providing the answer to a design problem, the use of Rollpin resulted in recognizable labor savings in assembly because it does not require hole reaming or secondary "locking" operations.

If you use taper pins, set screws, rivets, hinge pins or any other pin type fastener, consider redesigning with Rollpin for a faster assembly at lower cost.

MAIL COUPON FOR DESIGN INFORMATION— ROLLPIN® TRADEMARK

Elastic Stop Nut Corporation of America
Dept. R48-64, 2330 Vauxhall Road, Union, N. J.

Please send me the following free fastener information:

☐ Rollpin Bulletin
☐ Elastic Stop® nut bulletin
☐ Here is a drawing of our product. What fastener would you suggest?

Name_____ Title_____
Firm_____
Street_____
City_____ Zone_____ State_____

nonexistent for heavily loaded oscillating bearings in the 300 F to 1200 F range," according to Battelle technologist C. M. Allen. "Bearings and lubricants for airframe applications are not available which can be operated beyond 1200 F."

The mechanism of failure at elevated temperatures is not known except that above a certain temperature level, depending upon the material, surface fatigue may not be the dominating cause of failure. According to Allen, failure might progress as a result of creep or plastic flow and wear.

An evaluation of currently available bearings to obtain design data and information on failure constitutes the first phase of the program. It will include a survey of a number of bearing producers and users to aid in determining some of the problems involved in the use of antifriction bearings.

Meetings

AND EXPOSITIONS

August 11-15—

American Society of Mechanical Engineers. Heat Transfer Conference to be held at the Pennsylvania State University, University Park, Pa. Additional information can be obtained from society headquarters, 29 W. 39th St., New York 18, N.Y.

August 12-15—

Society of Automotive Engineers. West Coast Meeting to be held at the Olympic Hotel, Seattle. Further information is available from society headquarters, 485 Lexington Ave., New York 17, N.Y.

August 20-23—

Western Electronic Show and Convention to be held at the Cow Palace, San Francisco. Additional information can be obtained from Wescon headquarters, 342 N. La Brea, Los Angeles 36, Calif.

August 26-28—

Gas Dynamics Symposium to be held at the Technological Institute

of Northwestern University. Sponsors are the American Rocket Society and the university. Further information can be obtained from Dr. Ali Bulent Cambel, Gas Dynamics Laboratory, Northwestern University, Evanston, Ill.

August 28-30—

American Institute of Electrical Engineers. Pacific General Meeting to be held in Pasco, Wash. Additional information can be obtained from AIEE headquarters, 33 W. 39th St., New York 18, N.Y.

Sept. 4-6—

American Institute of Electrical Engineers. Magnetic Amplifiers Conference to be held at the Penn-Sheraton Hotel, Pittsburgh. Further information is available from institute headquarters, 33 W. 39th St., New York 18, N.Y.

Sept. 9-11—

American Institute of Electrical Engineers. Petroleum conference to be held at the Penn-Sheraton Hotel, Philadelphia. Further information can be obtained from AIEE headquarters, 33 W. 39th St., New York 18, N.Y.

Sept. 9-12—

Society of Automotive Engineers Inc. Tractor Meeting and Production Forum to be held at Hotel Schroeder, Milwaukee. Additional information is available from society headquarters, 485 Lexington Ave., New York 17, N.Y.

Sept. 9-13—

Instrument Society of America. 12th Annual Instrument-Automation Conference and Exhibit to be held in the Public Auditorium, Cleveland. Further information can be obtained from Herbert S. Kindler, Director of Technical Programs, ISA, 313 Sixth Ave., Pittsburgh 22, Pa.

Sept. 17-20—

American Die Casting Institute. Annual Meeting to be held at the Edgewater Beach Hotel, Chicago. Additional information is available from institute headquarters, 366 Madison Ave., New York 17, N.Y.

Sept. 23-24—

Steel Founders' Society of Amer-

(*Concluded on Page* 36)

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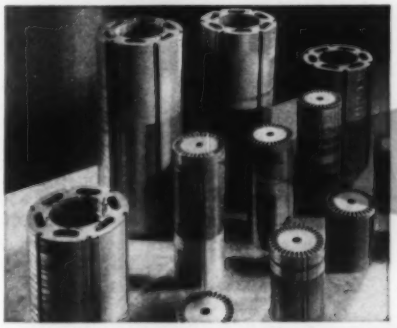
Increased motor production,
lower inventories in your plant through flexibility and dependability of Motork production schedules and raw material supplies.

Improved motor performance . . .
designs can be held to closer limits for greatest unit cost reduction. Quality standards are assured by the Motork Evaluator.



Lowest motor core cost
by the use of equipment and metallurgical methods designed to put Motork 10 years ahead.

Careful studies of MOTORK Laminations in all common motor types have been made in Magnetic Metals Company laboratories. Results prove advantages of MOTORK over conventional laminations. Reports of these studies are available.

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Electromagnetic Cores and Shields

Circle 422 on page 19

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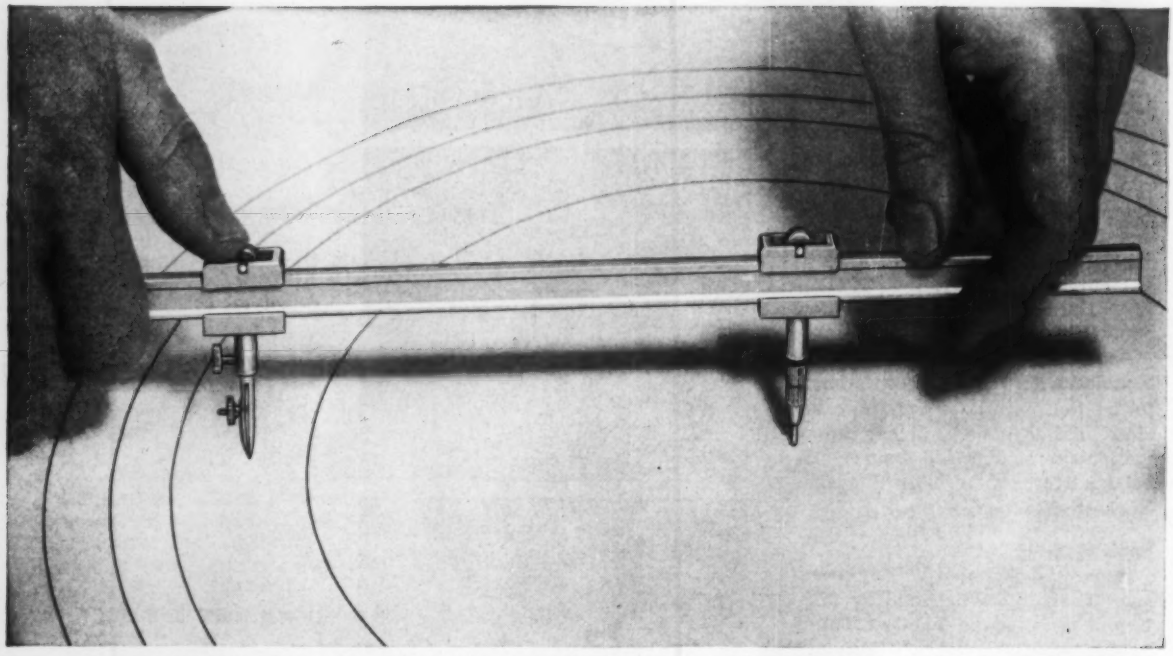
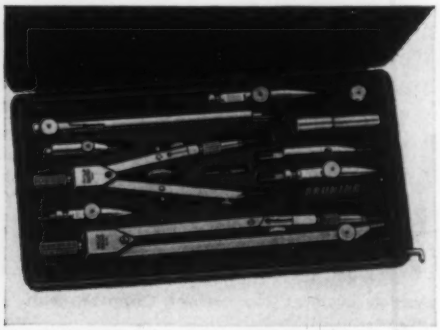
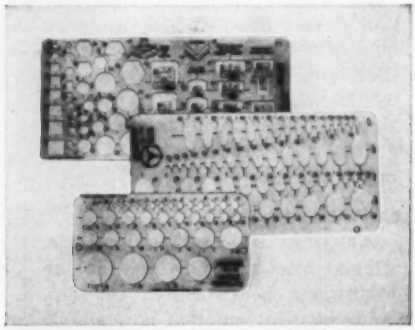


Thumb Adjusting Beam Compass. One hand does it! Your thumb moves a knurled thumb roller, located on top of the assembly slide, to the radius desired. Same hand then moves compass to draw circle or arc. It's fast, easy, and accurate. Constructed of anodized aluminum. One of the lightest, sturdiest and least expensive beam compasses on the market. Comes with pencil, pen, and needle parts and 13″ beam (25″, 38″, and 50″ beams also available).

Paramount Giant Bow Compass. Draw truer circles — ⅛″ to 11″ diameter — faster and easier! Improved center thumbscrew and headpiece bearings eliminate any free play at any setting. Durable nickel silver construction.



Stainless-Supreme Drawing Instruments. Get the higher precision, lifetime durability, and beauty offered only by instruments made entirely of stainless steel. Will not tarnish or suffer damage by perspiration. Five times harder than instruments made of brass or German silver. Specially hardened, swivel-type ruling pen blades are easy to clean, will remain sharp. Swiss precision-made.



RapiDesign Drafting Templates. Make neater, more uniform drawings and diagrams, save hours of drafting time. Choose from a wide assortment of styles containing symbols and shapes for every type of drawing—including mechanical, electrical, structural, architectural layout. Precision-cut from wear-resistant plastics to assure long lasting accuracy and durability.

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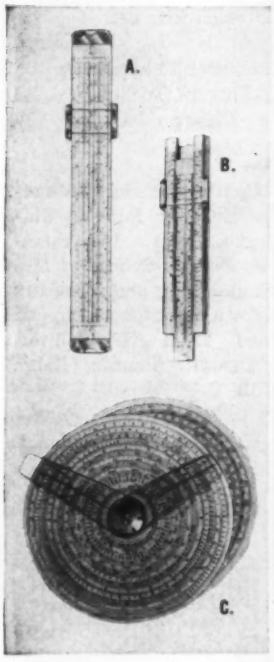
The *right* tool or material for the job, whether it's a large or small item, means a lot in drafting! That's why the drafting aids featured here are important to you. That's why they are important members of Bruning's complete quality line. Try them! You'll be mighty pleased at how fast the savings of time and labor mount up.

Researcher, manufacturer, and supplier . . . Bruning provides you a single, convenient, dependable source for everything you need in drafting room supplies and service. You assure yourself of top quality, simplify ordering and stocking, save time and money. With the most comprehensive network of sales-service branches and distributors in its field, Bruning assures you of getting the product you need when you need it!



A. "Eye-Saver" Slide Rule. Unique green-yellow color promotes faster, easier, more accurate readings. It prevents reflected glare, brings scales into sharp focus, provides optimum contrast with scale graduations. Rule cannot be damaged by moisture and severe use, is unaffected by temperature changes.

B. Pocket Companion Slide Rule. Get the right answers faster with this handy, high quality, inexpensive pocket slide rule. Durable molded plastic construction, brilliantly white with deep, easy-to-read graduations. Only 6" long weighing ¾ of an ounce, it has all nine standard scales. Handsome leather sheath.

C. Binary Circular Slide Rule. A real time-and-work saver for the draftsman and machine designer. One setting gives drill size for any size tap with any thread, can be read in 64ths, .001-inches, millimeters, and drill letters or numbers. Contains 25 scales.

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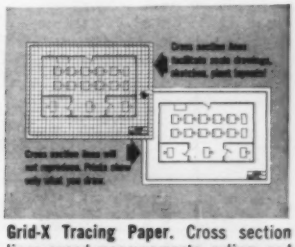
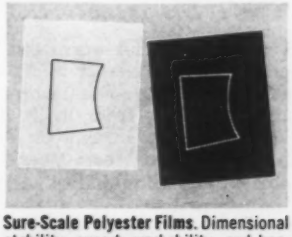
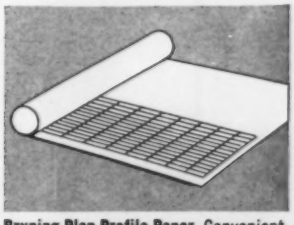


Grid-X Tracing Paper. Cross section lines speed measurements, ruling, and lettering, but will not reproduce—your prints show only the lines you draw. Pads, sheets, and rolls.



Sure-Scale Polyester Films. Dimensional stability, superb workability, and handling ease! Recommended for highly accurate to-scale drawings and as a basis for precision templates. Scribe or pencil surfaces.



Bruning Plan-Profile Paper. Convenient, time-saving medium for plan-profile combination drawings. Draw profile on the ruled half; use the blank half for plans, etc. Ideal for road construction drawings.

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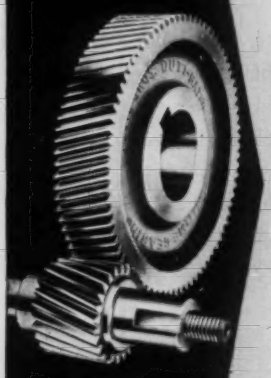
at Production-Run Prices

Foote Bros. Offers Engineered Helical and Worm Gear Sets FROM STOCK

1638 Duti-Rated COMBINATIONS



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*Horsepower Ratings....1 to 200**
*Center Distances.....2" to 12"**

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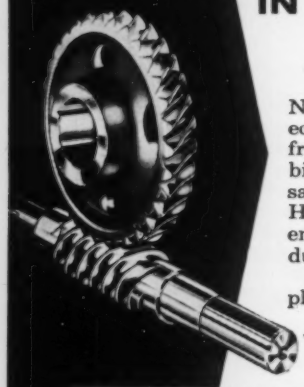

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† Tooling available for larger worm gear sets, engineered, but not stocked, to 200 HP and 18" centers. Prompt deliveries.

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Let us help you select standard helical or worm gearing to meet your special requirements, or, let us design and build your complete unit. Place your gear problems in the hands of experienced power transmission and gear engineers. Your inquiry is invited, and there's no obligation.

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Better Power Transmission Through Better Gears
FOOTE BROS. GEAR AND MACHINE CORPORATION
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News Roundup

(*Continued from Page 33*)

ica. Fall Meeting to be held at The Homestead, Hot Springs, Va. Additional information can be obtained from society headquarters, 606 Terminal Tower, Cleveland 13, O.

Sept. 23-26—

Association of Iron and Steel Engineers. Annual convention to be held at the Penn-Sheraton Hotel, Pittsburgh. Further information is available from association headquarters, 1010 Empire Bldg., Pittsburgh 22, Pa.

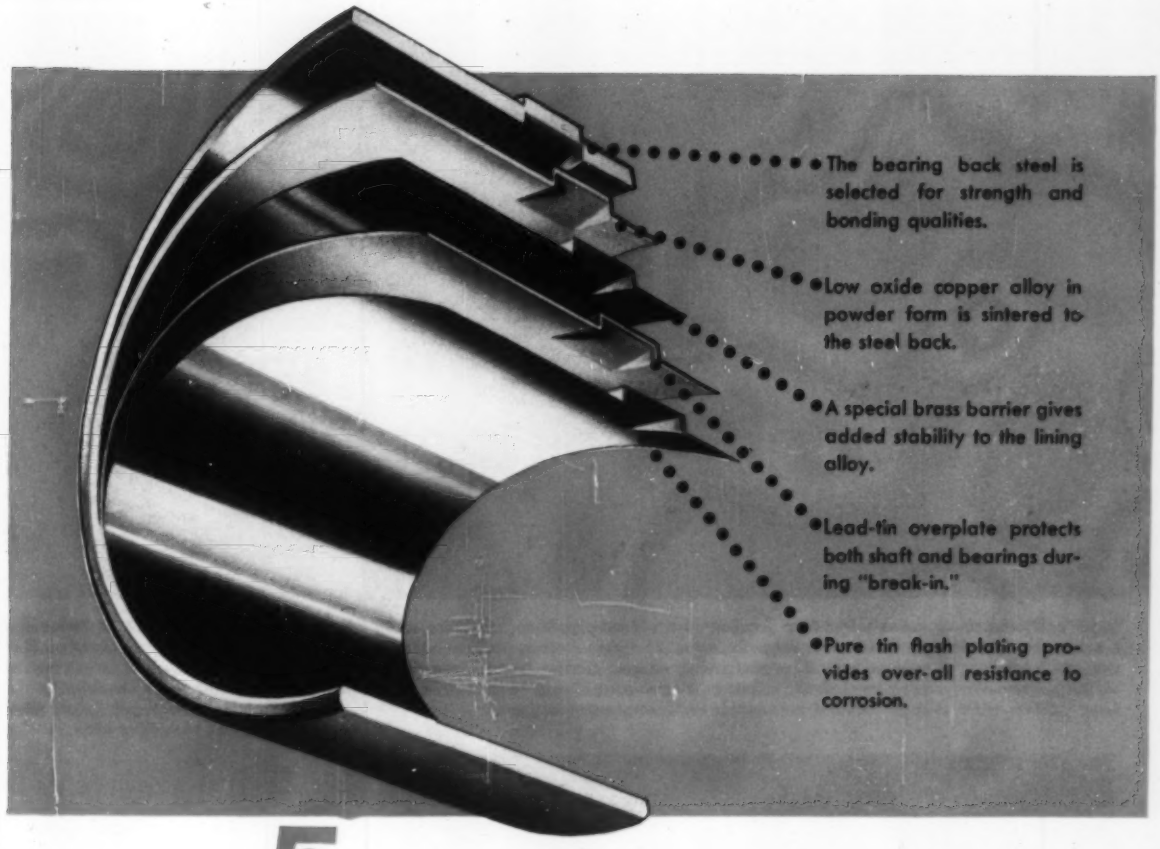
Sept. 24-25—

Sixth Annual Industrial Electronics Symposium to be held at the Morrison Hotel, Chicago. Sponsors are the Institute of Radio Engineers and the American Institute of Electrical Engineers. Further information can be obtained from H. L. Garbarino, Armour Research Foundation of Illinois Institute of Technology, 10 W. 35th St., Chicago 16, Ill.

Oct. 14-15—

Fourth Conference on Mechanisms to be held at Purdue University, West Lafayette, Ind. Sponsors are the Purdue School of Mechanical Engineering and MACHINE DESIGN. Additional information can be obtained from the Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

"Only trouble with your machine—"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Low oxide copper alloy in powder form is sintered to the steel back.
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Development of our low oxide copper-lead powder made possible the type of bearing essential for today's high-speed and heavy-duty engines. In this powder, each dust-like granule is a balanced alloy of copper and lead, *in controlled proportion*. This is the "ingredient" that creates greater bearing load-carrying capacity needed in high speed, high temperature engines. If you would like to know more about Federal-Mogul copper-lead alloy and its different applications, address:

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Circle 425 on page 19

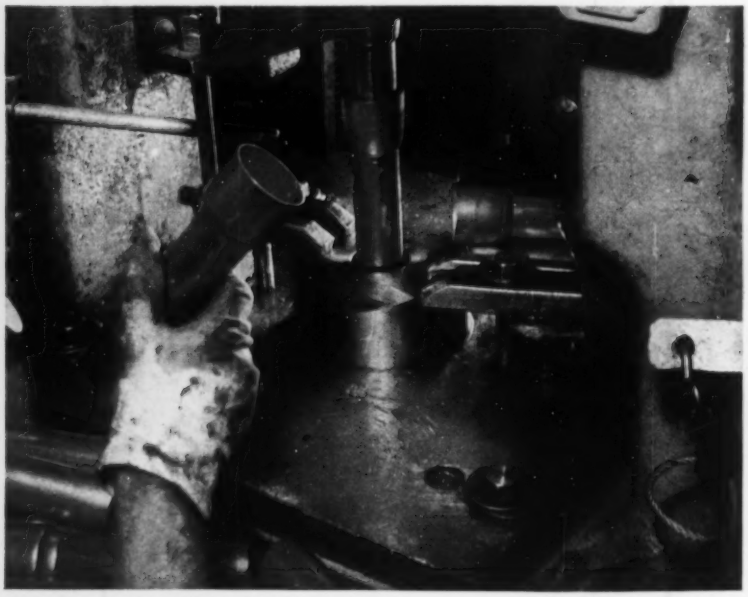
Circle 426 on page 19→

Steel's Strength, Copper's Fluidity (sealing ability) and corrosion resistance all are combined in Sterling Automotive Mfg. Co.'s use of Thomas copper-coated steel strip. By lubricating dies during punch press forming, copper coating boosted die life by 33%. The Chicago company turned to Thomas electro-coated strip to give its auto head gaskets extra strength needed for today's high-compression engines.

20 Million Shoe Horns a Year are made in Crawfordsville, Ind., plant of Steel Industries, Inc., where Thomas Strip saves up to 40% of production cost. From nickel-coated Thomas Strip, shoe horns get bright, shiny finish with only ball-burnishing after forming.

New Ways To Cut Costs With Thomas Strip

How Six Manufacturers Use These Production Ideas For Better Products



Ray-O-Vac Company saves $100,000 a year at its Clinton, Mass., Flashlight Division, by using Thomas copper-coated strip for flashlight cases. Compared to brass, Thomas deep-drawing strip is fabricated faster, requires less processing — also, copper coating lubricates dies and provides good chrome-plating base.

Manufacturers pictured on these pages chose Thomas Strip because it cuts costs, improves products—gives them higher profits and increased sales.

Pre-coated Thomas Strip is furnished ready for use with electroplated coatings of zinc, copper, brass, nickel, or chrome . . . or hot dip coated with lead alloy or tin . . . and coated with clear or colored lacquer.

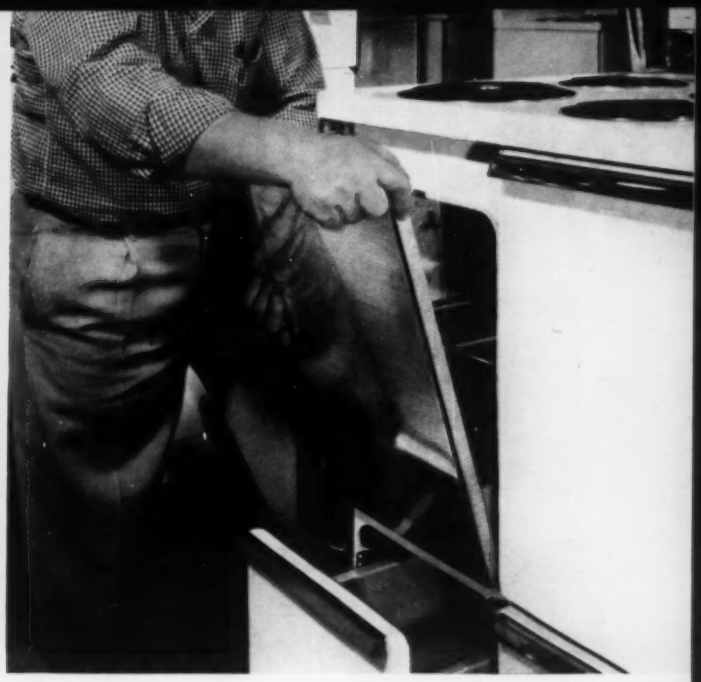
Uncoated Thomas Strip products include low carbon, alloy and high carbon spring steel grades. All are available in a wide range of sizes, gages, tempers and finishes.

You also can get cold rolled Thomas Strip plain or coated with a rolled-in pattern design of your choice.

All Thomas Strip products can save you money and enhance your product in six important ways:

- **Fabricates Easily**—coated steels stand fully as much fabrication as uncoated strip.

Increased Saleability and Profits followed Pioneer Can Co.'s switch from lithographed tin plate to brass-coated Thomas Strip with a rolled-in pattern design. Pioneer's waste baskets and decorative cans gained in durability, beauty and re-use value. They command a higher price now and return more profits.



General Electric's styling of its deluxe range made at Appliance Park calls for liberal use of pattern-rolled Thomas Strip. Deeply rolled rib design, satin chrome-coated, is used on oven door—adds distinctive modern touch to GE's Keyboard Ranges. Thomas offers many design patterns in plain or coated steels.

- **Longer Die Life**—most coatings lubricate dies, reduce wear and increase tool life.
- **Maximum Pieces Per Pound**—precision rolling to extremely close size tolerances gives more square feet of strip per ton.
- **Lower Plating Costs**—coatings can serve as final product finish or as base for further plating or painting.
- **Speeds Fabrication**—Thomas Strip coatings eliminate costly intermediate fabricating steps such as cleaning, buffing, even plating.
- **Steel's Strength and Economy**—are combined with beauty and utility of more expensive metals.

All the savings and benefits Thomas Strip specialties are giving to fabricators shown here are available to you. A national sales staff—familar with design and fabrication advantages of Thomas Strip is ready to serve you.

Write for samples, and additional cases of users' actual experiences with Thomas Strip Products. Do it today.

Stack 'n Add is another new product of Quaker Industries, Kenosha, Wisc. The smart sectional shelving gets strength, beauty and economy through use of Thomas brass-coated, buffed and lacquered strip for upright supports. Electro-coated Thomas Strip eliminates expensive pre-forming preparation, as well as costly plating.

Thomas Strip®
Division
Pittsburgh Steel Company
Grant Building · Pittsburgh 30, Pennsylvania

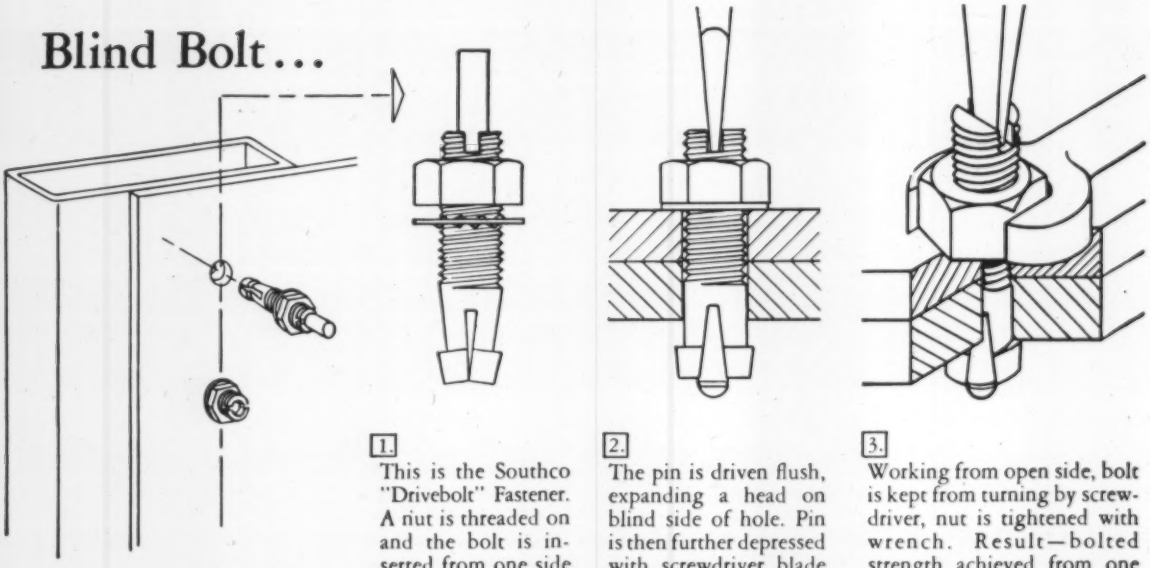
District Sales Offices:

Atlanta	Columbus	Detroit	New York	Tulsa
Chicago	Dallas	Houston	Philadelphia	Warren, Ohio
Cleveland	Dayton	Los Angeles	Pittsburgh	

Simplified Bolting and Riveting in Blind Applications

For fastener applications accessible only from one side of the work, you can now bolt or rivet without special tools...

Blind Bolt...

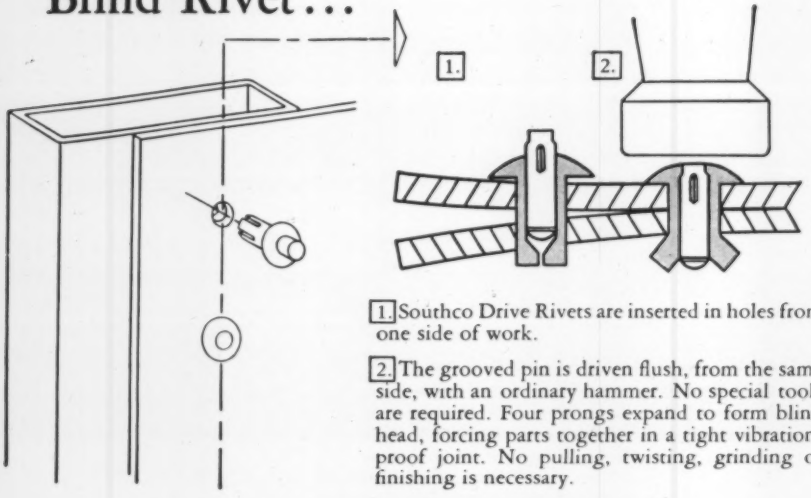


1. This is the Southco "Drivebolt" Fastener. A nut is threaded on and the bolt is inserted from one side of the work.

2. The pin is driven flush, expanding a head on blind side of hole. Pin is then further depressed with screwdriver blade to clear slot.

3. Working from open side, bolt is kept from turning by screwdriver, nut is tightened with wrench. Result—bolted strength achieved from one side of job.

Blind Rivet...



1. Southco Drive Rivets are inserted in holes from one side of work.

2. The grooved pin is driven flush, from the same side, with an ordinary hammer. No special tools are required. Four prongs expand to form blind head, forcing parts together in a tight vibration-proof joint. No pulling, twisting, grinding or finishing is necessary.

FREE!

Fastener Handbook

Send for your free copy of Fastener Handbook No. 7, just released. Gives complete engineering data on these and many other special fasteners. Fifty-two pages, in two colors.

Write on your letterhead to Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pa.

SOUTHCO FASTENERS

LION

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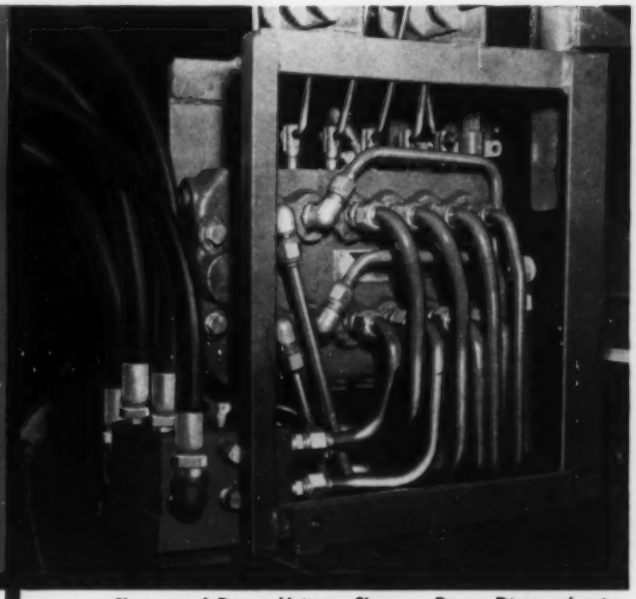
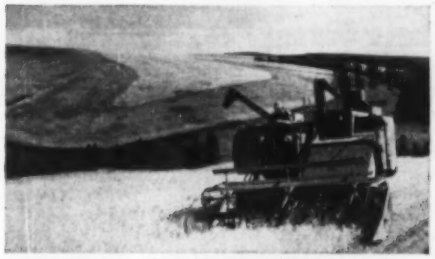
Circle 427 on page 19

FULL PAYLOAD POWER



Close-up of Power Unit on Sherman Power Digger showing direct power delivery from *lever to load*. Pilot model equipped with Eastman Hydraulic Hose and Tube Assemblies.

International Harvester Model 75 Payscraper. First application of hydraulic steering on earth movers. USER OF EASTMAN EQUIPMENT.



Allis-Chalmers Model 100 ALL CROP Harvester. Steering brakes and header height hydraulically operated. USER OF EASTMAN EQUIPMENT.

Bucyrus-Erie Model H-5 Hydrocrane. Hydraulically controlled boom, out riggers and bucket. USER OF EASTMAN EQUIPMENT.

FOR FULL PAYLOAD POWER FROM LEVER TO LOAD

specify

Eastman

HYDRAULIC HOSE ASSEMBLIES

For full payload power—*from lever to load*—consistent with long-lasting service, safety and sound construction—always specify Eastman Hydraulic Hose Assemblies.

Eastman, *first in the field* of Hydraulic Hose Assemblies, developed many original engineering advantages in design, construction and assembly—time tested by *unequalled* years of experience.

Since Eastman pioneered in the very first applications of mobile hydraulic power . . . you will find Eastman Hydraulic Hose Assemblies used by many original equipment manufacturers who were pioneers in their respective fields also.

Let *their endorsement be your assurance* of the satisfactory hydraulic performance of your products, too—plus the prestige and competitive sales advantage that comes with quality Eastman Hydraulic Hose and Tube Assemblies—*the Standard of the Industry!*

It pays to write Eastman ***FIRST***. . .
because Eastman was first in the field of Hydraulic Hose Assemblies

Eastman *first in the field*

MANUFACTURING COMPANY, Dept. MD-6, MANITOWOC, WIS.

Circle 428 on page 19

Wagner Type RA Single-phase Motor
Repulsion-start Induction 1 through 5 hp.

NOW...Wagner's high starting torque Integral hp single-phase motor is available in the latest NEMA frame sizes!

The well-known Wagner Type RA Motor is the workhorse of the single-phase motor field. This repulsion-start, induction-run motor combines the best features of the repulsion motor in starting, with those of the induction motor while running at rated operating speeds—ideal for applications requiring high starting torque.

No other single-phase motor has its ability to continually start heavy loads or perform with such complete satisfaction under continuous service.

Specifically designed for compressors, pumps, machine tools, grinders, and conveyors; it is preferred for many other single-phase high inertia or heavy friction starting applications because of its ability to start such loads with low current and with minimum light flicker.

Let a Wagner field engineer show you how these motors can be applied to your needs. Call the nearest of our branch offices, or write us.

OLD FRAME SIZE	NEW FRAME SIZE
203	182
204	184
224	213
225	215
254	254U

4 pole (1750 RPM, 60 cycle and 1450 RPM, 50 cycle) ratings are interchangeable in mounting dimensions with capacitor-start motors of the same ratings.

Wagner Electric Corporation
SERVING INDUSTRY SINCE 1891

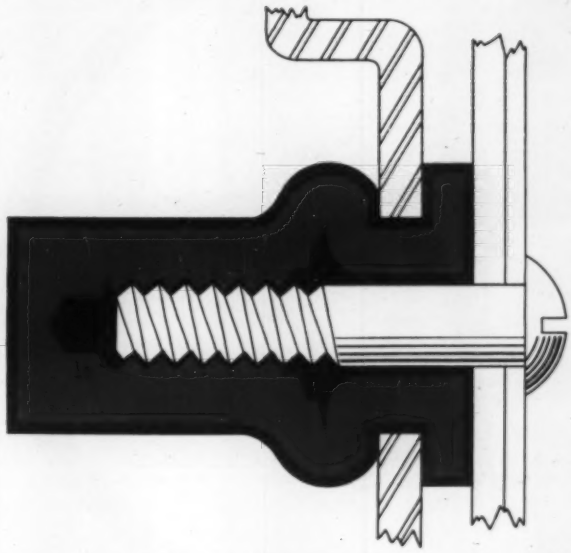
BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

Wagner Electric Corporation
6404 Plymouth Ave., St. Louis 14, Mo., U.S.A.

M57-11

ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES • AUTOMOTIVE BRAKE SYSTEMS—AIR AND HYDRAULIC

B.F.Goodrich Rivnuts®
boost profits by cutting assembly costs



RIVNUTS PROVIDE 6 THREAD NUTPLATES THAT STAY PUT, ELIMINATE WELDING, SPEED ASSEMBLY

Suppose you have to fasten a porcelainized sheet metal top to a frame assembly. You want to do the job as quickly as possible to keep down your production costs. You also want to be able to remove the top easily for servicing.

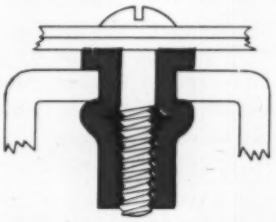
This is the problem that faced the manufacturer of automatic washing machines. He solved it by using Rivnuts, the *only* one-piece blind nutplate with threads. Upset from *one* side by *one* worker in seconds, Rivnuts provided a nutplate—solid as a rivet—with six clean threads for screw attachment. No matter how many times the top is removed, Rivnuts stay firmly in place with threads intact.

Before selecting Rivnuts, this manufacturer considered several conventional fastening methods. None of them appeared satisfactory. Bolts would hold the top, but the nuts would drop down inside if the top were removed. Self-tapping screw might tear loose. And the cost of installing welded nutplates was prohibitive—might have caused warping of the thin sheet metal.

By using Rivnuts, time was saved two ways: in factory assembly and in maintenance later on. B. F. Goodrich Rivnuts have speeded up thousands of similar operations and helped provide better, stronger products with greater eye appeal, beauty and sales appeal. No doubt they can do the same for you. Just write B. F. Goodrich Aviation Products outlining your problem. Our engineers will determine which Rivnut will do the job.

RIVNUTS SOLVE THE PROBLEM WHEN OTHER FASTENING METHODS FAIL

RIVNUTS

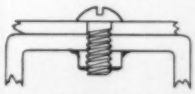


Installed from one side. Gives the strength of 6 clean threads. Provides firm, accurate nutplate. Installed in seconds by one person after enameling.

SELF-TAPPING

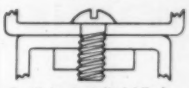
No structural strength. Tears loose easily. Lacks quality. Limits refastening.

WELDING



Requires tapping, cleaning, etc. Must be done before enameling. Gives fewer threads. Costs too much.

NUTS



Can't be installed blind. Drop down inside during removal. Difficult to install.

SEND NOW FOR FREE RIVNUT DEMONSTRATOR

Demonstrates with motion how you can use Rivnuts to fasten *with* and *to*. Explains construction, simplicity of installation. Get your free copy by writing to: B. F. Goodrich Rivnuts, Department MD-67, Akron, Ohio.

B.F.Goodrich

B.F.Goodrich Aviation Products

a division of The B. F. Goodrich Company, Akron, Ohio

Circle 430 on page 19

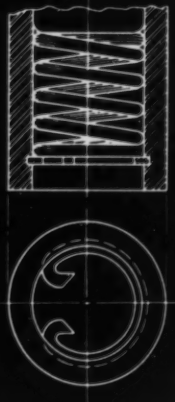
MEMO TO ENGINEERS—

Simplify your designs with—

NATIONAL RETAINING RINGS

Request Catalogs Today—

or ask a NATIONAL Sales Engineer to give you the facts on your particular design application at your convenience.



...eliminate costly shoulders

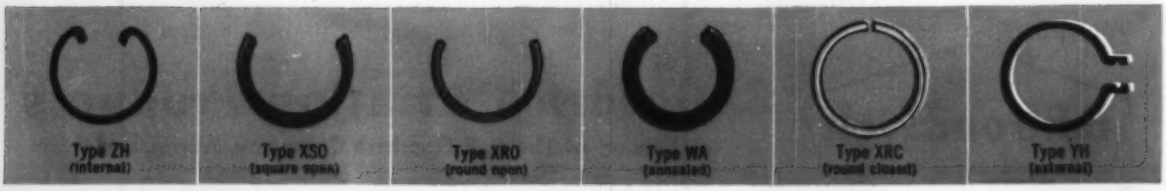
...groove smaller shafts and housings

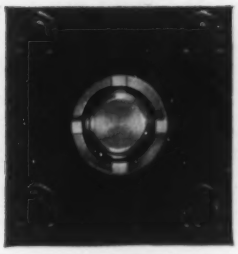
Installing NATIONAL Retaining Rings in simple grooves permits the use of smaller shafts and housings . . . saves machining and material wasted when larger shafts are cut down to make shoulders. Thousands of performance-proven applications include heavy machinery, engines, drill presses, tools, toys . . . products of metal, plastics and wood. Simplify the design of your products by utilizing the high efficiency of these easily installed NATIONAL Retaining Rings. Save weight, space, material, production and assembly time!

THE NATIONAL LOCK WASHER COMPANY

Serving Industry Since 1886

NEWARK 5, NEW JERSEY • MILWAUKEE 2, WISCONSIN





Here are the world's finest power cylinders

...competitively priced!

This ad is written for the man who has thought all cylinders are "pretty much alike." That just isn't so, and your Hannifin man would like an opportunity to show you why...

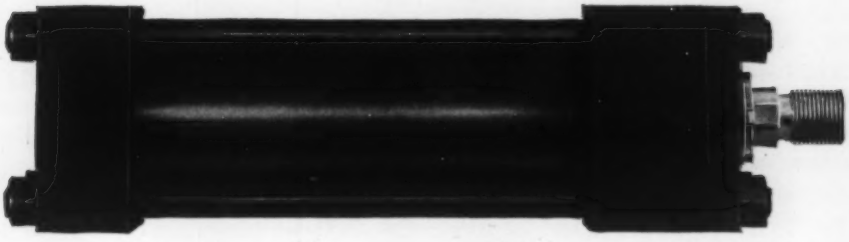
He'll show you design features that other cylinders simply do not have... extra quality workmanship at critical points that pays off in longer life ...accessibility that simplifies their infrequent maintenance. And when he talks price and delivery, you will find these better features cost you no more, can often be delivered sooner.

We think you'll agree that it pays to standardize on Hannifin cylinders.

AIR AND HYDRAULIC

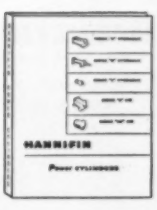
HANNIFIN

POWER CYLINDERS



COMPLETE CYLINDER FILE

Write for your copy of this new Hannifin Cylinder File . . . complete, easy-to-use, easy-to-order-from information on five lines of Hannifin Cylinders. Write Hannifin Corporation, 515 S. Wolf Road, Des Plaines, Ill.



Circle 432 on page 19

for low cost inert gas arc welding of mild steel

The Aircomatic arc welding process using carbon dioxide gas as the shielding medium, means high economy and speed in certain mild steel welding applications.

Fabricators of mild steel products such as car frames, fuel tanks, water heaters, trailer frame supports and pedal levers report outstanding results and substantial savings through this new technical development.

This combination of Aircomatic equipment (manual or automatic) and CO_2 is particularly recommended for high production work where the faster welding speeds and the inexpensive shielding gas will most benefit the cost conscious user. It is an ideal process for single pass applications and multiple pass applications. Joining sections of large diameter steel pipe is but one example.

If you weld mild steel, investigate the possibilities and advantages of using the Aircomatic process in your particular operation. Complete information and literature is available. Write Airco today!

AT THE FRONTIERS OF welding PROGRESS YOU'LL FIND . . .

AIRCO®

Offices and dealers in most principal cities

AIR REDUCTION SALES COMPANY

A division of Air Reduction Company, Incorporated
150 East 42nd Street, New York 17, N. Y.

On the west coast — Air Reduction Pacific Company
Internationally — Airco Company International
In Cuba — Cuban Air Products Corporation
In Canada — Air Reduction Canada Limited

Products of the divisions of Air Reduction Company, Incorporated, include: **AIRCO** — industrial gases, welding and cutting equipment, and acetylenic chemicals • **PURECO** — carbon dioxide — gaseous, liquid, solid ("DRY-ICE") • **OHIO** — medical gases and hospital equipment • **NATIONAL CARBIDE** — pipeline acetylene and calcium carbide • **COLTON** — polyvinyl acetate, alcohols, and other synthetic resins.

FAST FASTENERS FOR FASTER PRODUCTION

With the race on for better products at lower costs, production men everywhere are turning to time and labor saving devices of all types. Eaton-Reliance Keps will fasten assemblies in a minimum of time with a maximum of efficiency.

The tooth type washer preassembled, freely rotating on the nut, permits a quicker assembling of the part, time savings, increased production, an elimination of lost parts, and exactly balanced inventories. They are made to "funnel" onto the bolt providing easy starts.

Keps can be hopper fed thus providing the additional advantage of automatic assembly. Investigate this new efficient fastening device and profit by these savings as hundreds of other quality product manufacturers are now doing.

Additional information supplied upon request or a Fastening Engineer will call without obligation.

EATON — RELIANCE DIVISION
MANUFACTURING COMPANY
506 CHARLES AVENUE • MASSILLON, OHIO

SALES OFFICES: New York • Cleveland • Detroit • Chicago • St. Louis • San Francisco • Montreal

PRODUCTS: Sodium Cooled, Poppet, and Free Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Rotor Pumps • Motor Truck Axles • Permanent Mold Gray Iron Castings • Heater-Defroster Units • Snap Rings Springtites • Spring Washers • Cold Drawn Steel • Stampings • Leaf and Coil Springs • Dynamatic Drives, Brakes, Dynamometers

Circle 434 on page 19

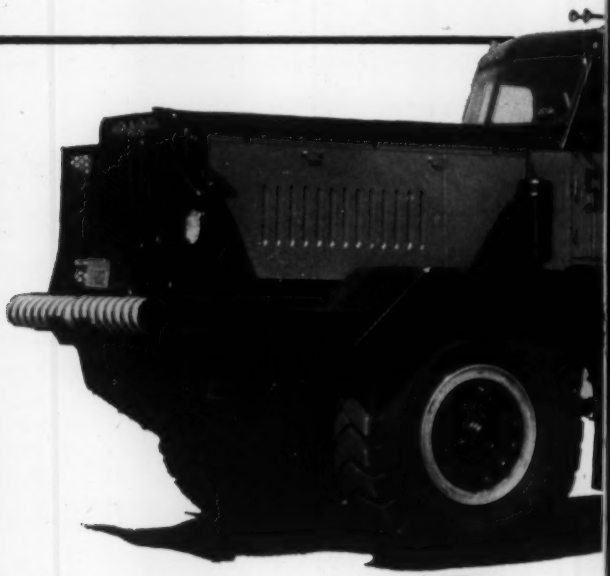
Meets high formability requirements —saves 24% weight

Here's a job that may surprise quite a few steel users accustomed to thinking of high strength steel as being "stiff" and therefore not readily formable. For in making these LP-gas containers, USS MAN-TEN Steel blanks ¼" thick are press-formed *cold* into seamless shells, 29" in diameter and 24" deep. Such an operation calls for a degree of formability that would be considered high even for carbon steel.

By taking advantage of this property, Pressed Steel Tank Co., Milwaukee, Wisc., was able to reduce the shell thickness of this Hackney container 24%, and at no increase in cost, produce a stronger, tougher and more durable container that is 102 lbs. lighter than when made of carbon steel. This saving in weight means easier handling in the shop and during installation, plus substantial savings in freight costs—both on the steel used and when finished containers are shipped.

Assures greater portability, prolongs life

In portable oil drilling rigs like this, every pound of weight saved is of vital importance. To keep weight as low as possible without sacrificing ruggedness, the Cardwell Mfg. Co., of Wichita, Kansas, has built the trailer frame and working platform of USS MAN-TEN Steel and reduced weight 6,000 lbs. as compared to structural carbon steel construction. In the 96-foot mast, which can be telescoped and folded down when the rig is moved, MAN-TEN Steel used in all the structural members reduces weight about 25%, and helps to keep moving costs down to a minimum. MAN-TEN Steel's superior strength and abrasion resistance, plus its high fatigue strength, also pay off by keeping the rig steadily on the job.



UNITED STATES STEEL
USS HIGH STRENGTH STEELS
1933 1957
24 YEARS OF PERFORMANCE

USS MAN-TEN Steel—the low cost way to build better performance into equipment like this

IN THE PAST 24 YEARS, USS MAN-TEN Steel has earned the high regard of design engineers—and for good reason.

Faced with the knotty problem of improving equipment, while at the same time keeping down its cost, they have found that with USS MAN-TEN Steel they not only could materially reduce weight—or greatly increase strength and durability—but often could do so at *lower* cost than with structural carbon steel.

For USS MAN-TEN Steel, although it costs only about 25% more, has a yield point at least one and one half times that of structural carbon steel. It has greater abrasion resistance. Its fatigue strength is about 40% higher. Its resistance to atmospheric corrosion is twice that of carbon steel. In addition, USS MAN-TEN Steel is more readily worked and welded than structural carbon steel of the same strength level.

Thus when MAN-TEN Steel is used in the same thickness as structural carbon steel, it will increase strength 50% at only about 25% increase in material cost. And when used in 20 to 25% thinner sections, MAN-TEN Steel construction, though lighter, may be designed for *both* greater strength and lower cost.

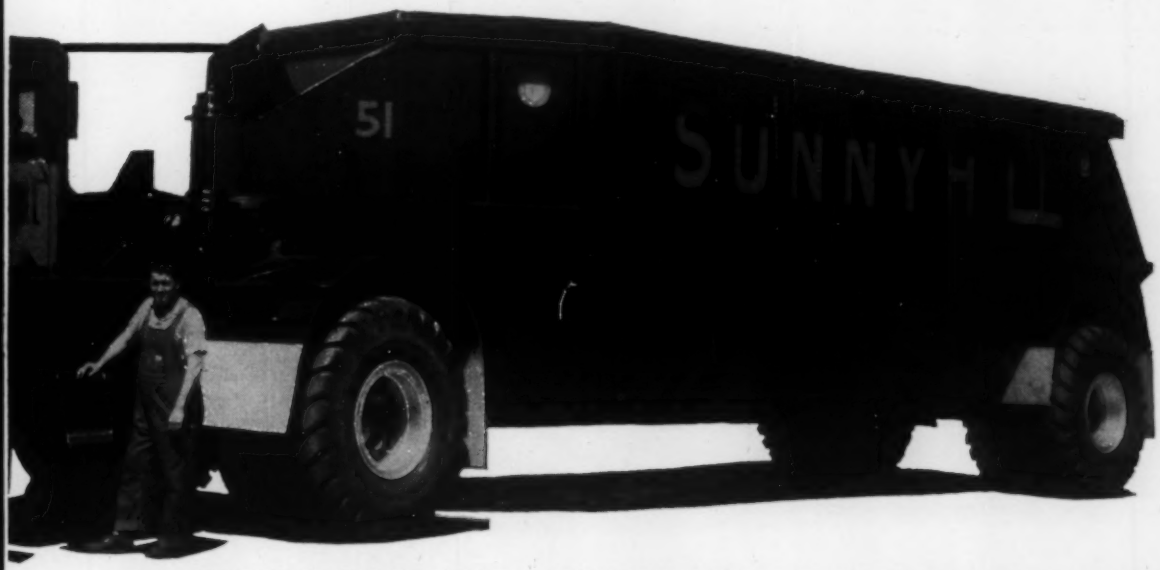
The increased working capacity, longer life and greater freedom from maintenance its use ensures are money-saving advantages that pay off BIG in customer satisfaction and increased salability.

To find out how you can incorporate USS MAN-TEN High Strength Steel in your designs most efficiently and economically, send for our 174-page "Design Manual for High Strength Steels." This authoritative book covers every facet of this important subject. For your free copy, write—*on your company letterhead*, giving your title or department—to United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

Cuts weight 15%, increases payload capacity 15%

This 50-ton Dart coal hauler is a classic example of how USS MAN-TEN Steel can solve a difficult weight problem. Large trucks like this are generally designed right up to the limit of tire capacity. In other words, their size is largely determined by the maximum combined weight of truck and payload that the tires can safely carry. Thus the 15% reduction in body weight made possible by lighter MAN-TEN Steel construction, by lifting that much weight off the tires, enabled the designers to increase the payload capacity by a highly desirable 15% so that the truck is able to carry a huge 50-ton load on rough, off-road hauls without undue jeopardy to tire life.

Ten trucks like this, built by Dart Truck Company, Kansas City, Kansas, have been in use more than three years at Sunnyhill Coal Company's New Lexington, Ohio, workings. Each hauls an average 120,468 tons per year. To date, none has required repair of any kind. All are still in perfect condition.



UNITED STATES STEEL CORPORATION, PITTSBURGH • AMERICAN STEEL & WIRE DIVISION, CLEVELAND • COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
NATIONAL TUBE DIVISION, PITTSBURGH • TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA. • UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS HIGH STRENGTH STEELS

USS MAN-TEN • USS COR-TEN • USS TRI-TEN

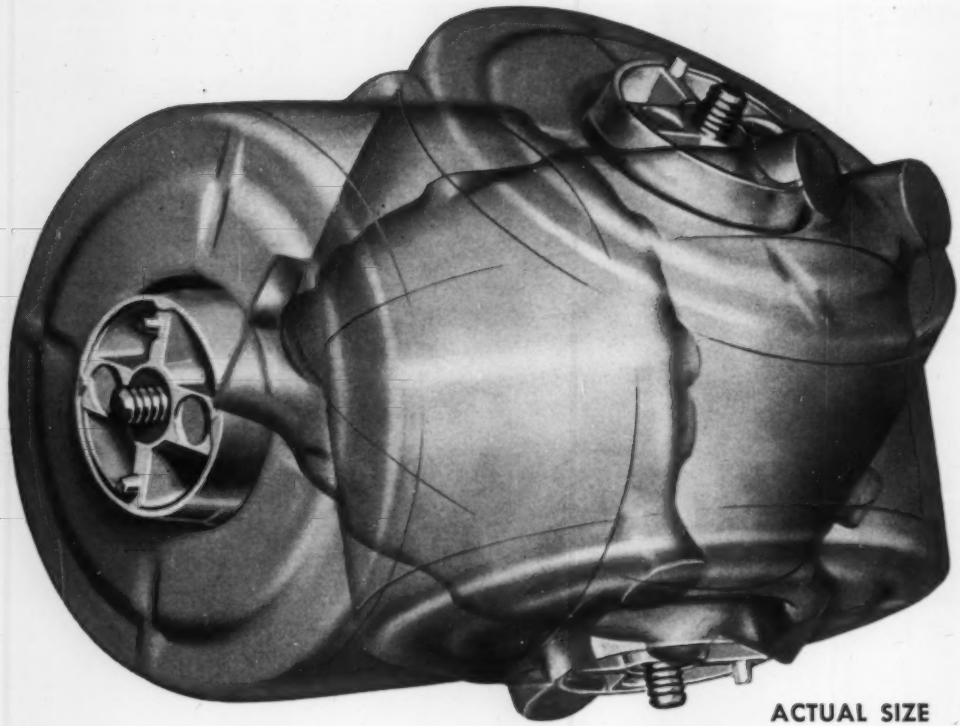
USS, MAN-TEN, COR-TEN and TRI-TEN are registered trademarks of United States Steel

Circle 435 on page 19

7-1022

UNITED STATES STEEL

For All-Angle Operation...



ACTUAL SIZE

New Lightweight Redmond Single-Bearing MonoMotor

This new all-angle single-bearing condenser fan MonoMotor was developed specifically for the refrigeration and air conditioning industries in answer to modern demands for a smaller, lighter, yet more powerful motor. It is adaptable for a multitude of applications where a long-life quality motor is needed that will give years of continuous service-free use at low operating cost.

All-angle operation of the AM-4 is achieved through a special thrust bearing and pin assembly. The rotor end play is controlled to very close tolerances, which makes possible the mounting of the motor in any position without the rotor floating in the bearing.

With the new Redmond positive oiling system the AM-4 is guaranteed not to leak oil in all-angle use or in shipment. This design provides an extra large oil reservoir for lifetime lubrication. Positive oiling is achieved through the forced recirculation of the lubricant, which is completely suspended and uniformly distributed in pure wool and nylon wicks.

The basic AM-4, rated at 1½ through 16 watts, is 4-pole, 1550 RPM, 115 volts, 50/60 cycles, and is available in odd voltages and frequencies.

It will pay you to obtain complete information about this new motor by sending for the literature described below.

Send for Complete Performance Data

Write for the "AM-4 Bulletin"—it contains complete information on the design features, dimensions, performance, and operational data.

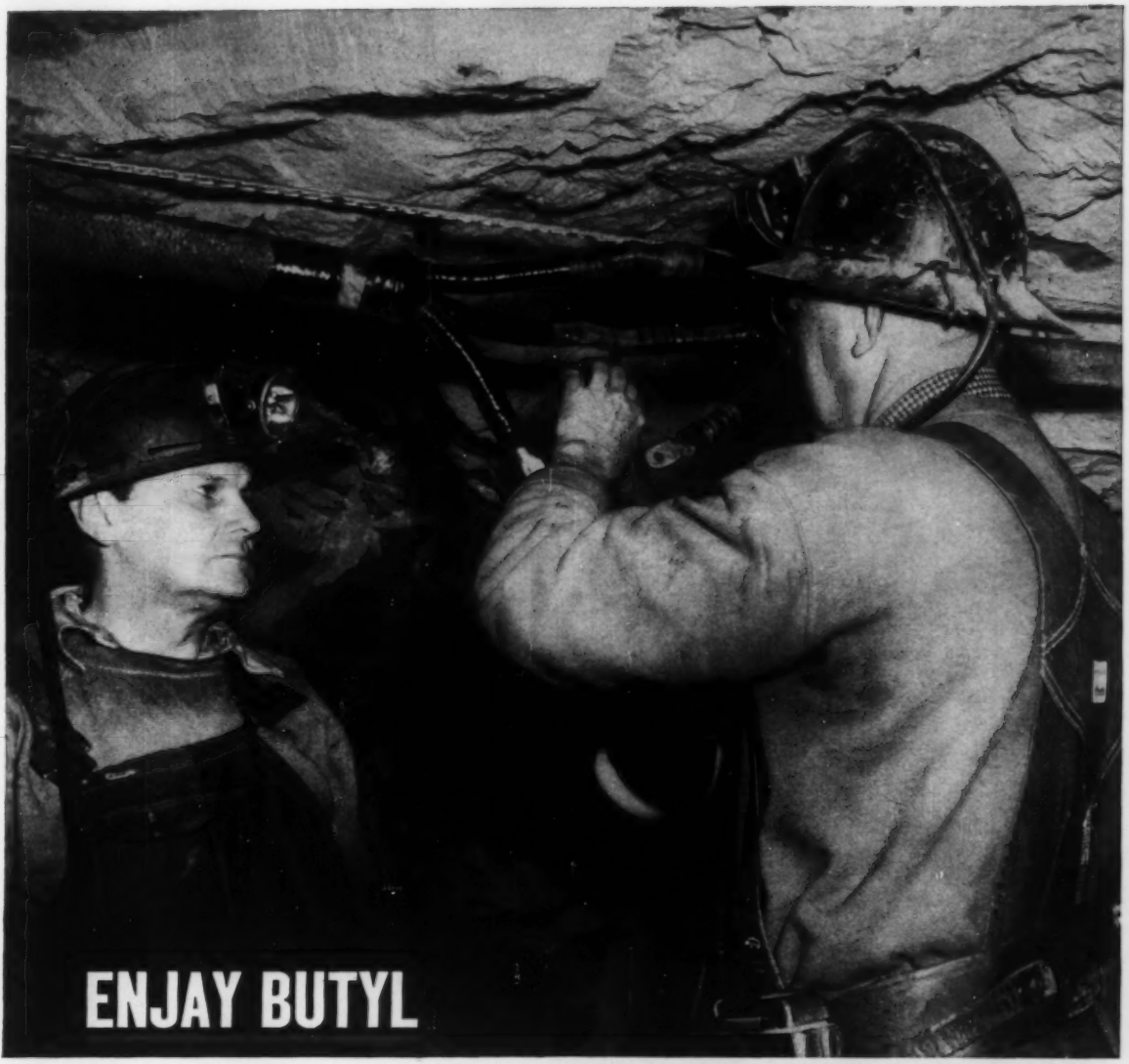
The Standard of Dependability

Redmond COMPANY Inc.
OWOSSO, MICHIGAN

ADVERTISED IN The Saturday Evening POST

THE BIG NAME IN SMALL MOTORS

Circle 436 on page 19



electrical wonder rubber OFFERS TRIPLE VALUE

Performance! Versatility! Economy! In all three, Enjay Butyl is the world's outstanding rubber value. In laboratory tests, and a wide variety of applications, no other rubber has matched Enjay Butyl's ability to resist ozone and corona, impact and abrasion, moisture and weathering . . . properties that make Enjay Butyl-made products *outstanding* performers.

Underground service cables, transformer housings, high-voltage industrial cables . . . in these, and many other electrical applications, Enjay Butyl outperforms and out-lasts *all other* types of rubber, synthetic *or* natural. *Low-in-cost* and *immediately available*, this truly wonder rubber may well be able to cut costs and improve performance in *your* products. For further information, and for expert technical assistance, contact the Enjay Company.

ENJAY

Pioneer in Petrochemicals

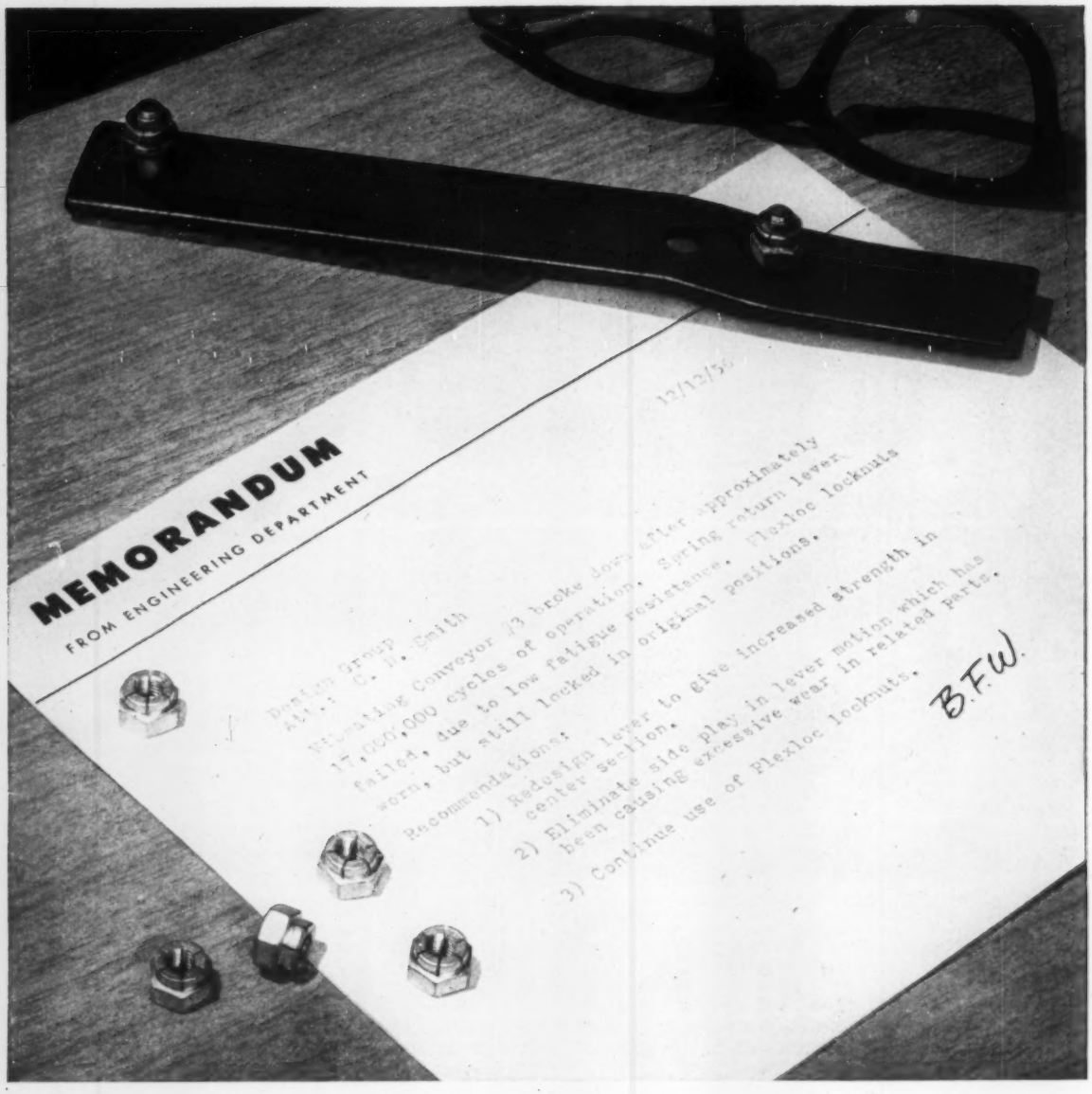
ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.

Other offices: Akron • Boston • Chicago • Los Angeles • New Orleans • Tulsa

ENJAY BUTYL

Enjay Butyl is the greatest rubber value in the world . . . the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

Circle 437 on page 19


MEMORANDUM
FROM ENGINEERING DEPARTMENT
12/12/56
Design Group
Att.: C. B. Smith
Vibrating Conveyor #3 broke down after approximately
17,000,000 cycles of operation. Spring return lever
failed, due to low fatigue resistance. Flexloc locknuts
worn, but still locked in original positions.
Recommendations:
1) Redesign lever to give increased strength in
center section.
2) Eliminate side play in lever motion which has
been causing excessive wear in related parts.
3) Continue use of Flexloc locknuts.
B.F.W.

Why designers specify FLEXLOC self-locking nuts

Where products must be tough . . . must stand up under vibration, shock and abuse . . . designers specify rugged, reliable, precision-built FLEXLOC self-locking nuts as fasteners.

HERE'S WHY:

FLEXLOC locknuts are strong: tensile strengths far exceed accepted standards. They are uniform: carefully manufactured to assure accurate, lasting spring tension in the flexible locking collars. And they are reusable: rough screw threads, repeated removal and replacement, frequent adjustments will not affect their locking life.

Standard FLEXLOC self-locking locknuts are available in a wide range of standard sizes and materials, to meet the most critical locknut requirements. Your authorized industrial distributor stocks them. Write us for complete catalog and technical data. Flexloc Locknut Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

FLEXLOC® LOCKNUT DIVISION

STANDARD PRESSED STEEL CO.

SPS

JENKINTOWN PENNSYLVANIA

Circle 438 on page 19

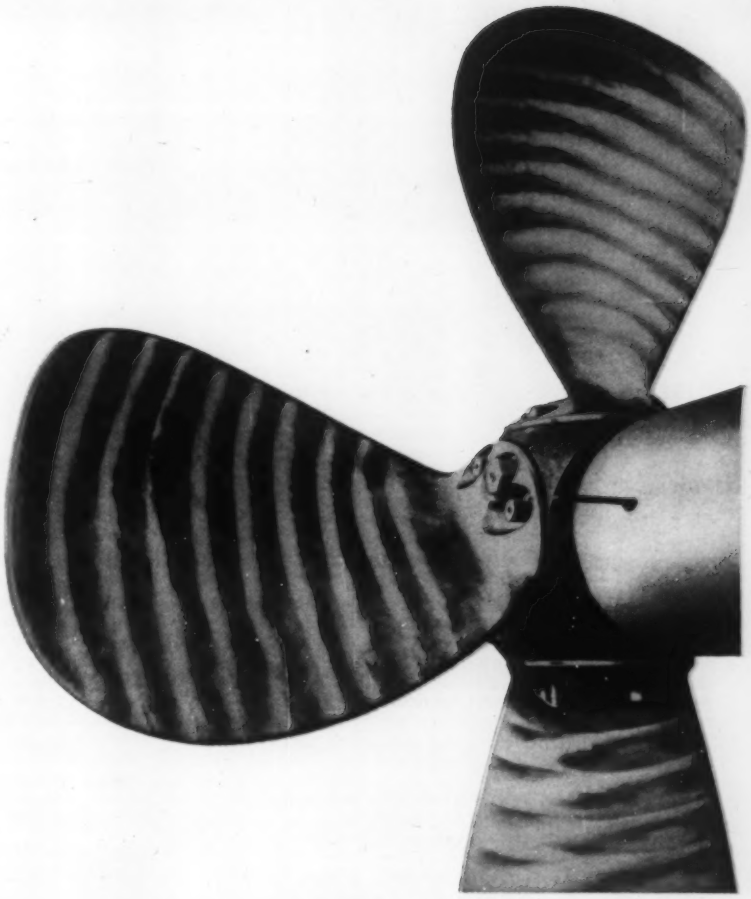
STAINLESS STEEL MAKES THE DIFFERENCE

...its effect on modern castings

Through modern casting techniques, you can get all the useful qualities of stainless steel in everything from small intricate parts to large precise shapes.

For example, stainless steel is giving giant ship propellers new toughness and resistance to corrosion and erosion. This means that peak speeds and efficiency can be sustained much longer. The "work hardening" property of stainless steel minimizes wear and cuts operating risks, too.

This combination of stainless steel and casting techniques gives design engineers a powerful tool to improve the effectiveness and "sales appeal" of their designs. For more information, write: ELECTRO METALLURGICAL COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y.



Ingeniously constructed of four blades and hub, cast separately and bolted together, this stainless steel propeller defies corrosion and erosion . . . maintains "original design" efficiency.

METALS DO MORE ALL THE TIME ...THANKS TO ALLOYS

Electromet
FERRO-ALLOYS AND METALS

UNION CARBIDE

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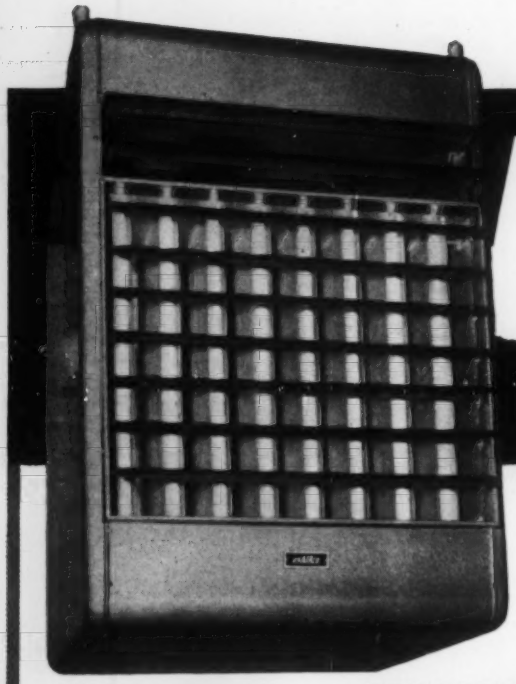
Circle 439 on page 19

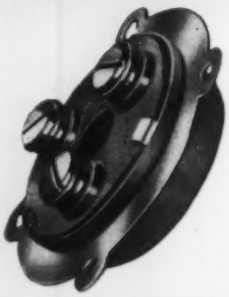


Another Famous Name

STERLAIRCO, INC. 260 North Elm Street, Westfield, Massachusetts

MANUFACTURERS OF USAIRCO GAS FIRED UNIT HEATERS

Joins the growing list of heating equipment manufacturers who depend on KLIXON *Snap-Acting* CONTROLS



Sterlairco, Inc., of Westfield, Massachusetts, is an old customer among the list of leading manufacturers of heating equipment who have incorporated KLIXON Snap-Acting Controls in their equipment.

There are many reasons why so many designers of heating equipment specify and use Klixon Controls:

1. **Applications can be worked out in the laboratory for optimum performance.**
2. **This laboratory performance is assured in the field because the unit can be shipped and installed as a package.**
3. **There are no adjustments for people to tamper with in the field.**
4. **Millions of Klixon Thermo-Snap Controls are in daily use in thousands of different industrial and military applications.**

Here's what C. E. Scott, Vice President of Sterlairco, Inc., has to say about the application of Klixon Controls in USAIRCO gas fired unit heaters:

"The application of a high limit control on gas fired unit heaters demands complete dependability of operation and we have found that the Klixon Control has continually met our demands of performance."

And here's what other heating equipment manufacturers have to say about Klixon Controls:

AUTOMATIC GAS EQUIPMENT CO., Pittsburgh, Pa.
"We have been using KLIXON Controls for over 15 years and have found them to be very durable and dependable."

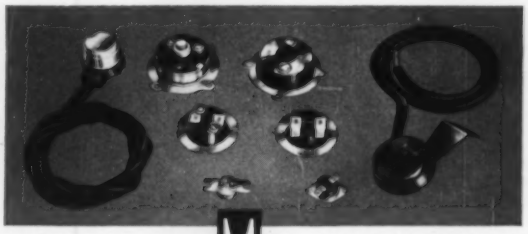
MORRISON STEEL PRODUCTS, INC., Buffalo, N. Y.
"We have used thousands of KLIXON Controls on our heating equipment for over 10 years and have found . . . them . . . thoroughly dependable and they reduce problems to a practical minimum."

YORK-SHIPLEY, INC., York, Pa.
"We insist on KLIXON Controls in our house heating boilers because we find they accurately control unit operation."

CARRIER CORPORATION
"We have used KLIXON Controls on our units for six years and have always found them to be dependable, service free and in accordance with specifications."

Klixon Controls are available in many hermetically sealed and open types in a wide variety of operating temperature ranges. Klixon engineers, specialists in temperature control applications, can help you work out your specific application details. Write for their help or for complete details.

Typical KLIXON Snap-Acting Thermostats used in many applications, including examples of the new 202 series for home appliances.



METALS & CONTROLS CORPORATION

Spencer Thermostat Division 3206 Forest Street, Attleboro, Mass.

KLIXON

LINK-BELT P.I.V. means positive, infinitely variable speed control

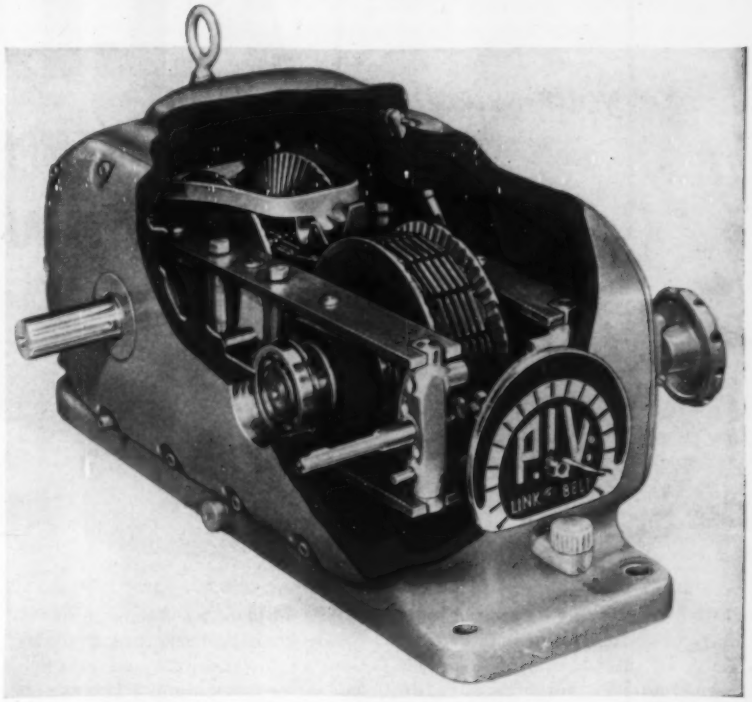
Where modern production machines and operations demand extremely accurate transmission of power with variable speed control, no other variable speed drive can match the efficiency of the Link-Belt P.I.V. Here's how it works.

•

Because it employs an exclusive metal, self-tooth-forming chain, Link-Belt P.I.V. permits instant and accurate speed changing without perceptible loss of speed—regardless of load. And the variation can be accomplished without stopping the driven machine.

A mere turn of the control screw simultaneously varies effective diameters of conical wheels located on the input and output shafts. In turn, these radially grooved wheels mesh with the self-tooth-forming chain assuring positive selection of speed.

Call your nearby L-B office for Book 2274.



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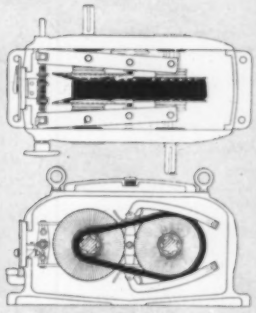
LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World.

14,318

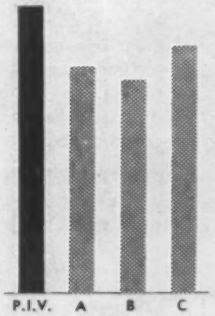
LONG-LIFE ACCURACY and application flexibility of Link-Belt P.I.V. are unmatched by any other variable speed drive. It's available in 8 sizes and 16 standard types, in capacities from ½ to 25 hp—for horizontal or vertical mounting. Compact design simplifies installation as a separate unit or a built-in part of a machine. Even greater application flexibility can be gained by making motor and helical gear sets integral parts of the P.I.V. Of all-metal construction, P.I.V. is totally enclosed, automatically lubricated.

How LINK-BELT P.I.V. differs from other variable speed drives

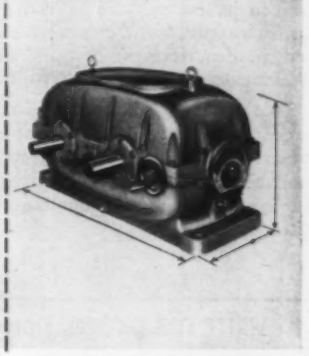
POSITIVE MESH of self tooth-forming chain with grooved wheels assures full-rated hp at output shaft. All-metal construction . . .



PREVENTS SLIPPAGE because the P.I.V. drive chain does not depend on friction and is unaffected by atmospheric conditions.



UNMATCHED ACCURACY is demonstrated by this actual comparison of maintained rpm of P.I.V. and three other variable speed drives.



GREATER COMPACTNESS results from short-center arrangement of drive mechanism. Some P.I.V. models save 50% on floor space.

Circle 441 on page 19

For your selection

ALTEMP

HIGH TEMPERATURE SUPER ALLOY STEELS

ALTEMP A-286 . . . an austenitic iron-nickel-chromium alloy made heat-treatable by the addition of titanium. Designed to maintain high strength and corrosion-resistance up to the 1350 F range, and to afford satisfactory scale resistance up to 1800 F.

A-286 was developed in the A-L Research Laboratory in Watervliet, N.Y., in the 1949-51 period. Among the high-strength, heat-resisting alloys, it has exceptionally low strategic alloy content, improved hot-working and machining qualities, and good center ductility in large sections. Currently used in jet engines and superchargers for such applications as turbine wheels and blades, frames, casings, afterburner parts, bolting, etc.

This alloy is readily produced in large quantities without the need of special steel-making equipment. It is available in the form of billets, bars, forgings, sheet, strip, tubing and hot-extruded shapes.

ALTEMP S-816 . . . a chromium-nickel-cobalt base alloy, strengthened by additions of molybdenum and tungsten, and with a columbium-carbon ratio of ten to one to insure its structural stability. Designed for high strength and corrosion-resistance service in the 1200-1500 F range, and at higher temperatures under lower stress conditions. Developed in the A-L Research Laboratory at Watervliet, N.Y. in the years of 1940-43, and engine-tested and proved for periods of over 30,000 hours.

S-816 is used currently for turbine blades in two of the production jet engines, also in a number of experimental aircraft and commercial gas turbines. Except for seamless drawn tubing, it is available in practically all forms and shapes in which stainless steels are processed, including hot extrusions.

ALTEMP S-590 was designed for service in the range of 1100-1400 F temperatures where high strength and corrosion resistance are required, and where cost is also a factor. Unlike S-816, which is practically a non-ferrous alloy, S-590 has a chromium-nickel-cobalt-iron base. However, it employs the same molybdenum and tungsten additives, and the same columbium-carbon ratio.

S-590 was developed at the Watervliet Laboratory and field-proved during the same years as S-816. It is available in the same shapes and forms, and is currently being used for turbine blades and wheels in experimental commercial gas turbines.

OTHER GRADES . . . among the many other Super Alloys made by Allegheny Ludlum are V-36, M-252, 19-9 DL, 19-9 DX and Waspaloy.

Do you have a high temperature problem? The services and experience of our Research Laboratories and Technical Staff are completely at your command. *Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.*

WSW 9310 B

WRITE FOR INFORMATION

Certified laboratory data on the properties of Allegheny Ludlum high temperature Super Alloy Steels are yours on request.

ADDRESS DEPT. MD-90

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Allegheny Ludlum

Stocks of AL Stainless Steels carried by all Ryerson warehouses

LEADING PRODUCER HIGH-ALLOY STEELS

Circle 442 on page 19

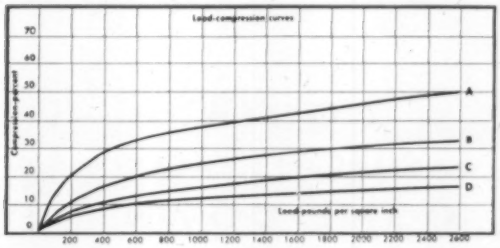
Accopac fiber gaskets offer new high in sealing efficiency

New materials seal at higher temperatures under light or heavy flange loads

The new, expanded line of Accopac® materials brings an entirely new degree of sealing efficiency and dependable performance to a wide range of fiber sheet gasket applications.

Where flange pressures are in the range of 800-2000 psi, there are Accopac compositions that contain cork for added compressibility and sealing efficiency at these relatively low unit loads. For heavy-duty jobs, where flange pressures are 2,000 psi or higher, there are other, more dense Accopac materials that contain no cork.

All Accopac compositions are made by an exclusive patented process, in which individual fibers are coated with a synthetic latex binder before the sheet is formed. This assures uniform distribution of binder and fibers, and the result is a strong, homogeneous material.



A major advantage offered by this process is that Accopac materials have unusual dimensional stability. Accopac gaskets won't shrink or grow in the flange—or in storage—because their synthetic binders are non-extractable and will not vaporize even at temperatures up to 250° F.

There are Accopac compositions made to meet virtually any combination of operating conditions. The chart below briefly describes various Accopac cellulose fiber materials and shows their characteristics and suggested uses. For more information, write Armstrong Cork Company, Industrial Div., 7006 Dean St., Lancaster, Pa.

Accopac cellulose fiber gasket materials

GENERAL CHARACTERISTICS	TYPE	CURVE	COMPOSITION, CHARACTERISTICS, AND USES	COMPRESSIBILITY* % 1,000 PSI	MINIMUM TENSILE AMD (PSI)
FOR FLANGE PRESSURES FROM 800-2,000 PSI For increased sealing efficiency at these relatively low unit loads, there are three Accopac materials that contain finely ground cork. These materials seal under bolt pressures as low as 800 psi and are recommended for applications where flange pressures are up to 2,000 psi and where temperatures do not exceed 250° F.	CS-301	A	Used to seal certain greases, high aniline point oils, water, and other services not involving aromatic fuels. Highly compressible material containing finely ground cork. Styrene-type (Buna S) rubber binder. Underwriters' approved.	30-45	800
	CN-705	A	Generally suitable for sealing lighter petroleum distillates (including gasoline) and water services. Highly compressible. Nitrile-type (Buna N) binder. Underwriters' approved.	30-45	1,000
	CN-808	D	This is a pre-compressed material in which the natural interstices have been closed by pressure. It seals at flange pressures as low as 800 psi. Generally suitable for sealing lighter petroleum distillates and water services. Nitrile-type (Buna N) binder.	5-15	2,200
FOR FLANGE PRESSURES OVER 2,000 PSI For heavy-duty flanges, where bolt pressures are 2,000 psi or higher, there are Accopac materials that contain no cork. These are dense formulations designed to take heavy loads with minimum extrusion and loss of bolt torque. Where temperatures do not exceed 250° F., they offer an economical substitute for compressed asbestos sheet packing.	N-820	C	Very high quality material recommended for heavy-duty flanges where bolt torque loss and extrusion must be held to minimum. Dense composition with low compressibility. Contains mineral filler. Nitrile-type (Buna N) binder.	10-20	3,000
	N-852	B	A low-cost, medium-density material recommended for medium to heavy-duty flanges. Moderate oil resistance. Binder is blend of synthetic rubbers, including nitrile-type (Buna N).	17-27	1,800
	N-854	B	A medium hard, oil-resistant composition for use with high flange pressures. Contains special mineral filler and nitrile-type (Buna N) binder.	15-25	2,500
	D-856	B	Recommended for medium to heavy flange pressures in services where chloroprene-type (neoprene) binder is preferred.	17-27	2,000

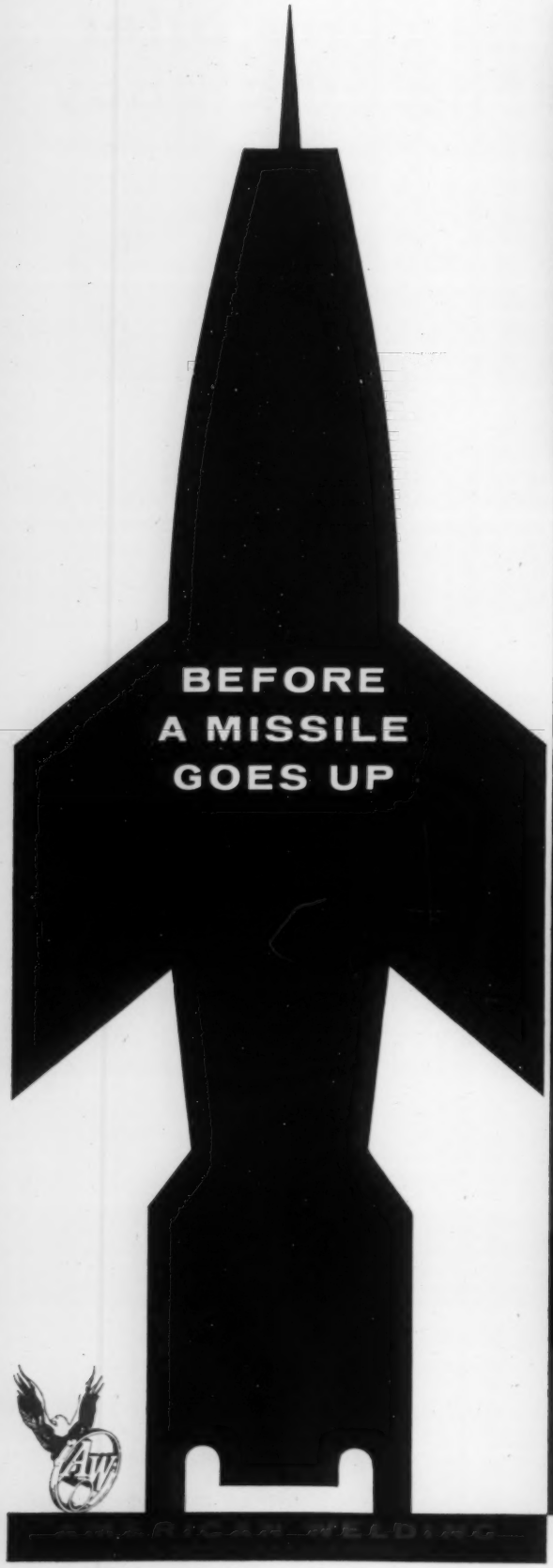
*Tested per ASTM D1147-53T

You'll find additional helpful information on the whole line of Accopac fiber sheet gasket materials—including the new Accopac asbestos fiber materials—in this new folder.

Armstrong ACCOPAC

. . . used wherever performance counts

Circle 443 on page 19



COSTS OUGHT TO COME DOWN

As America's missile and rocket programs progress from the experimental to the production stage, cost must necessarily be a big factor. Most missiles and rockets are expendable, one-shot units. This, too, makes cost a more important factor. American Welding's unique ability to form, flash weld and fabricate rings, circular components and other production parts is the answer to production costs.

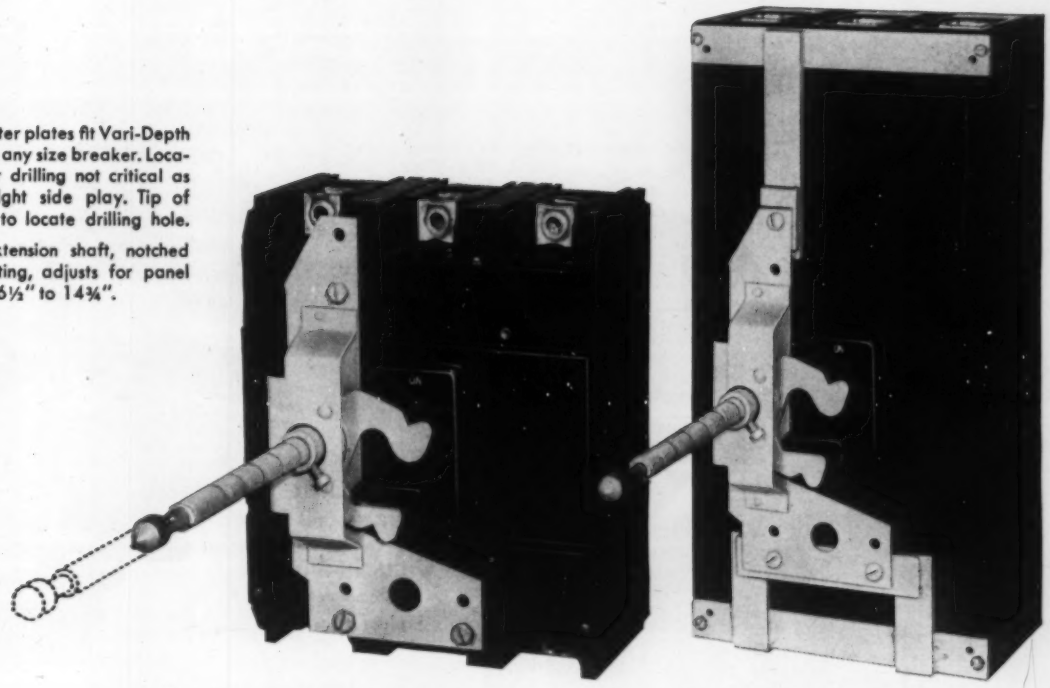
For further information, contact the Industrial Products Division of The American Welding & Manufacturing Company.

THE AMERICAN WELDING & MANUFACTURING CO.
130 Dietz Road — Warren, Ohio

Circle 444 on page 19

Simple adapter plates fit Vari-Depth mechanism to any size breaker. Location of cover drilling not critical as shaft has slight side play. Tip of shaft serves to locate drilling hole.

Threaded extension shaft, notched for easy cutting, adjusts for panel depths from 6½" to 14¾".

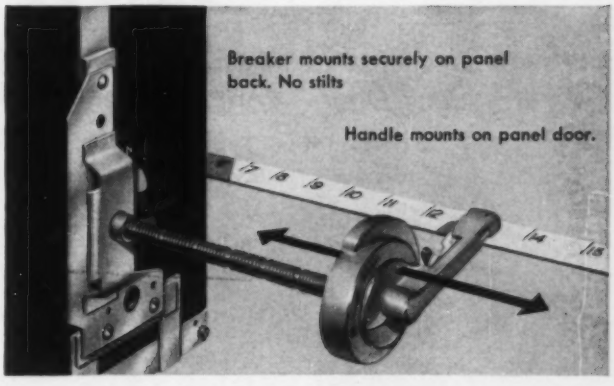


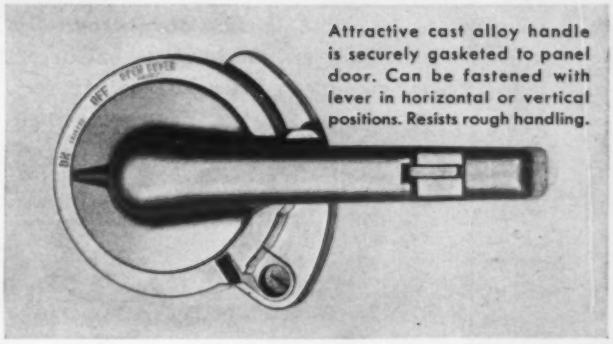
VARI-DEPTH extendible breaker handle simplifies panel mounting

It is easy to see why the Westinghouse Vari-Depth makes it possible to assemble AB circuit breakers or De-ion® switches in control panels of any depth with a great saving in time, labor and hardware. Makes a better installation, too, with these advantages . . .

- Extendible shaft adjusts to varying panel depths.
- Breaker mounts securely to back of panel. No stilts required.
- Only one simple door drilling for all Westinghouse breakers—Types E through KL and all De-ion switches.
- No brackets needed for door interlock.
- Complete hardware furnished.

Detailed information contained in booklet SA-7664. Write Westinghouse Electric Corporation, Box 868, Pittsburgh 30, Pa. J-30275

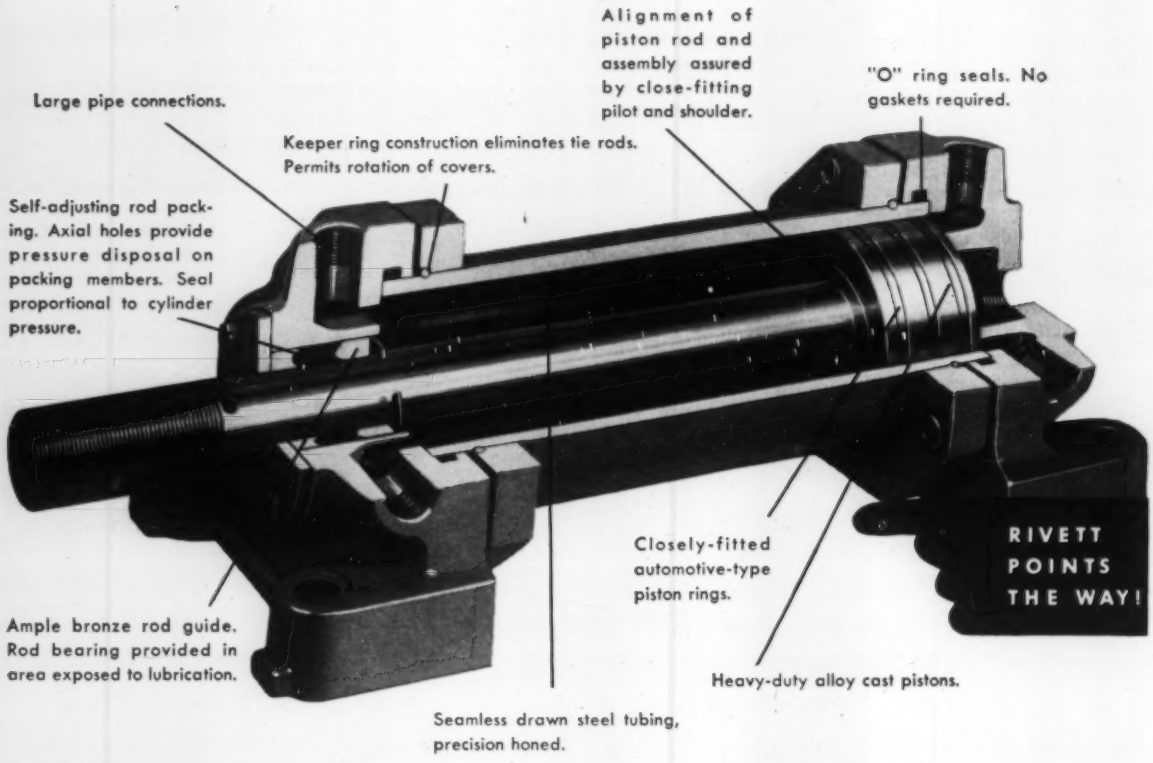




Attractive cast alloy handle is securely gasketed to panel door. Can be fastened with lever in horizontal or vertical positions. Resists rough handling.

YOU CAN BE SURE...IF IT'S

Westinghouse


Large pipe connections.
Alignment of piston rod and assembly assured by close-fitting pilot and shoulder.
"O" ring seals. No gaskets required.
Keeper ring construction eliminates tie rods. Permits rotation of covers.
Self-adjusting rod packing. Axial holes provide pressure disposal on packing members. Seal proportional to cylinder pressure.
RIVETT POINTS THE WAY!
Closely-fitted automotive-type piston rings.
Ample bronze rod guide. Rod bearing provided in area exposed to lubrication.
Heavy-duty alloy cast pistons.
Seamless drawn steel tubing, precision honed.

Sealing efficiency improves with increased pressure in Rivett 1500 PSI* Cylinders!

*Higher on application.

- External "O" Rings Act As Static Seals To Eliminate Gaskets And Assure LEAKPROOF OPERATION!
- Automotive Type Piston Rings Reduce Friction, Increase Sealing Ability, Permit Sensitive Response To Any Pressure.
- Keeper Ring Construction Eliminates Tie Rods.
- Self-Adjusting Rod Packing Cuts Friction.
- Unfailing Power For Millions Of Cycles.

1080 SELECTIONS!

7 mountings; 10 bores; standard and 2:1 over-size rod; single and double end rods; internal or external thread; cushioning either or both ends; special covers.

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Brighton 35, Boston, Mass.

Get Catalog No. 106 to aid your circuit design. Complete drawings, specifications, cut-away views, tables, diagrams!

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THE BETTER YOU KNOW HYDRAULICS THE BETTER YOU LIKE

RIVETT
"100"
HYDRAULIC CYLINDERS

Circle 446 on page 19

(Advertisement)

Helpful Data from DE LAVAL

How to calculate the efficiency of worm gearing

The efficiency of worm gearing is determined by frictional losses at the tooth contact, bearings and oil seals plus losses from oil churning and windage. A formula for efficiency at the tooth contact may be developed from a consideration of the forces at the contact. Figure 1 shows these forces acting on a developed section of the worm thread. For simplicity the pressure angle has been assumed to be zero.

The coefficient of friction of the worm and gear is a function of the materials, finish, lubrication and rubbing speed. The latter is the relative speed between a point on the pitch surface of the gear and one on the pitch surface of the worm. The coefficient of friction varies very little at high rubbing speeds but rises with increasing rapidity as the speed drops below 500 fpm.

The efficiency formula developed in Figure 1 involves worm lead angle and the friction angle. Figure 2 provides a relationship between friction angle and rubbing speed based on tests made on accurately manufactured gearing consisting of hardened and ground worm and bronze gear operating in oil.

The formula for rubbing speed is:

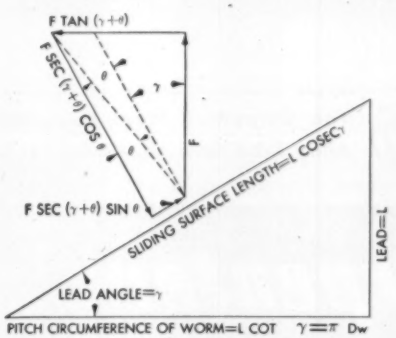
$$V = \frac{.262\ Dw \times \eta}{\cos \gamma}$$

where

$V =$ Rubbing speed – feet per minute
$Dw =$ Worm pitch diameter – inches
$\eta =$ Worm speed – rpm
$\gamma =$ Worm lead angle

FIGURE 1.

Development of equation for efficiency at contact between worm and gear



F=TANGENTIAL FORCE ACTING ON GEAR

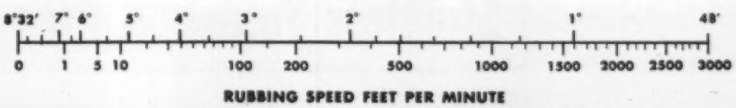
F TAN ($\gamma + \theta$) = TANGENTIAL FORCE APPLIED TO WORM

F SEC ($\gamma + \theta$) COS θ = FORCE NORMAL TO CONTACT SURFACE

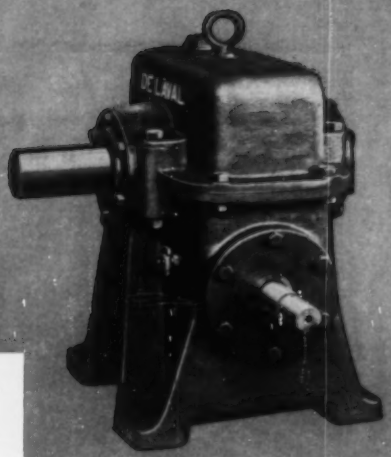
F SEC ($\gamma + \theta$) SIN θ = FRICTIONAL FORCE

$$\text{EFFICIENCY} = \frac{\text{WORK REALIZED}}{\text{WORK APPLIED}} = \frac{L \times F}{L \cot \gamma \times F \tan (\gamma+\theta)} = \frac{\tan \gamma}{\tan (\gamma+\theta)}$$

FIGURE 2.



Please direct inquiries to advertiser, mentioning MACHINE DESIGN

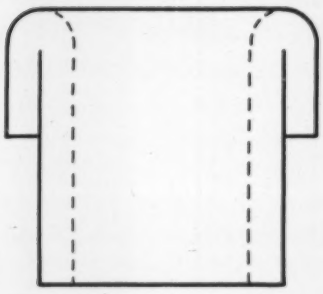


DE LAVAL Worm Gear Speed Reducers Offer Efficiencies to 96%

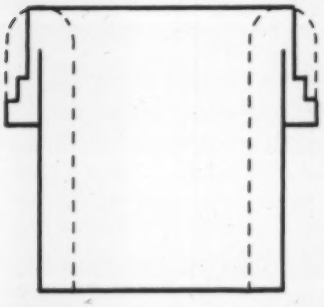
Ruggedly built for long efficient service De Laval speed reducers are made in horizontal and vertical single reduction units in ratios of 3:1 to 100:1. They are also available in double horizontal and vertical double reduction units as well as in helical-worm and double-worm design. Ratios from 37.8:1 up to 6400:1.

Write for your copies of Catalogs G-WBV and G-WWH to De Laval Steam Turbine Company, 858 Nottingham Way, Trenton 2, New Jersey

more proof of *Carpenter* quality . . . at no extra cost



Reverse bend is made on one end, doubling the pipe back on itself.



Machining is then performed on the doubled back part of the pipe as shown in photo.

Carpenter Stainless Pipe shows fabrication savings!

Only the highest quality stainless pipe and tubing with outstanding uniformity in properties and dimensions can take this punishing reverse bend (see sketches) and succeeding machining operations. The part is made from 2″ Carpenter Schedule 40 pipe, and must meet close tolerance requirements consistently.

If more of this kind of proof is needed, call your nearest Carpenter Distributor today. He has the service and stock to serve you right!

MEMBER

The Carpenter Steel Company
Alloy Tube Division, Union, N. J.

Export Dept.: The Carpenter Steel Co., Port Washington, N. Y.—"CARSTEELCO"

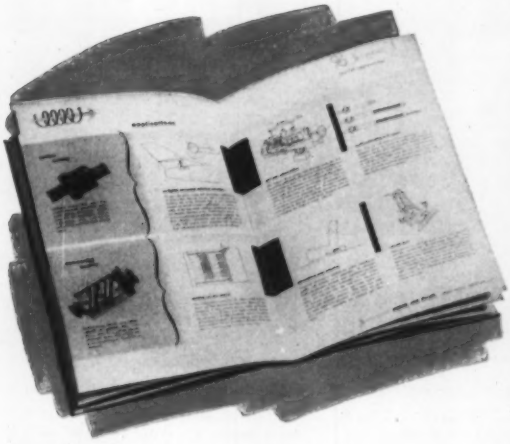
Carpenter

Stainless Tubing & Pipe

FREE! YOUR NEW ACTUATOR and SPLINE "PROBLEM SOLVER"!

New 1957 Engineering Data Book from World's Largest Producers of Ball/Bearing Screws and Splines

36 pages crammed with time-, work-, and money-saving facts: Principles • Types • Basic Operations • Coupling Methods • Efficiency • Versatility • Advantages • Selection Factors • Design Data • Sample Problems, etc.



SAGINAW b/b SCREWS are *90%-98% efficient* (compared to 15%-20% efficiency of Acme screws). Require ⅔ LESS torque and power for same linear output—with consequent weight, space reductions. Function normally at −75° to +250° F. Two types: precision-ground or commercial rolled-thread. Have been built 1½ in. to 39½ ft. long.

SAGINAW b/b SPLINES have *40 times lower coefficient of friction* than sliding splines; transmit or restrain high torque loads far better; permit vital power, weight, space reductions. Have been designed 3 in. to 10 ft. long.

Saginaw ball/bearing Screws & Splines

SAGINAW STEERING GEAR DIV., GENERAL MOTORS CORP., SAGINAW, MICH.

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Saginaw Steering Gear Division, General Motors Corporation
b/b Screw and Spline Operation
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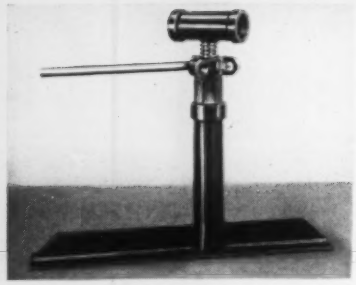
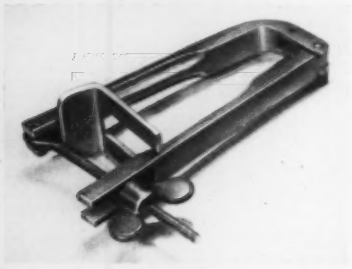
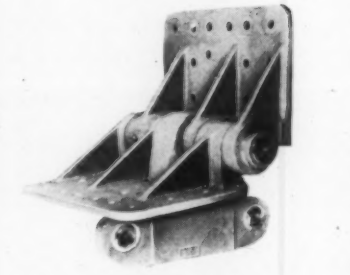
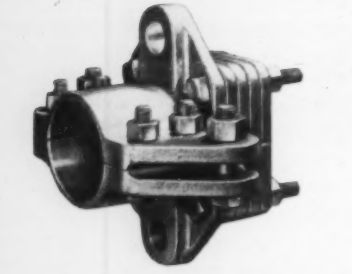
what you should know about

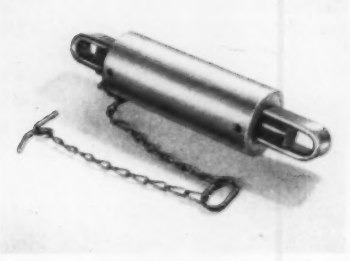
DS Finished Products Division











Originally developed to machine DS castings, this division has grown into a complete industrial fabricating plant. Here, facilities are available for producing finished products and components for a variety of applications, as well as contractual machine or assembly work in just about every metal *and material*. Shown here are just a few of the myriad of finished products and components produced at Dodge. Ask for bids on *your* contract work.

Write us today for complete details.

DODGE STEEL COMPANY

Finished Products Division

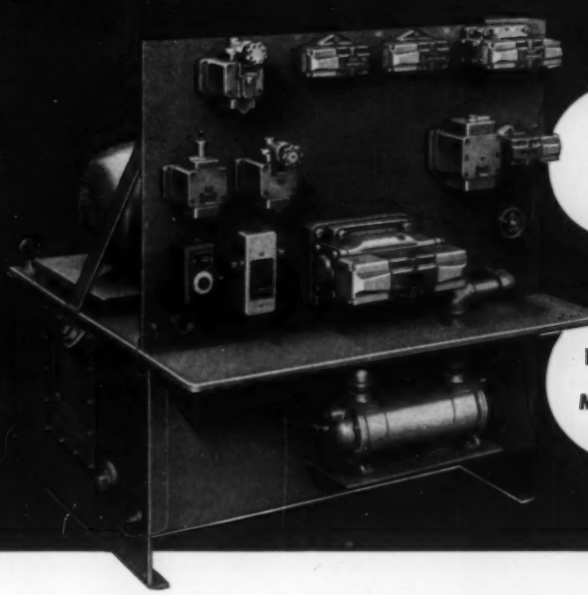
6501 Tacony Street • Philadelphia 35, Pa.

THE MOST IMPORTANT ALLOY IN A STEEL CASTING IS QUALITY

Circle 449 on page 19

It Takes MORE than a Collection of Parts

To Make A VICKERS CUSTOM BUILT POWER UNIT



Improve and Simplify Hydraulic Design

Reduce Installation and Maintenance Costs

A Vickers Custom Built Power Unit is much more than a collection of parts . . . just as the machines you build are more than the castings, shafting, gears, motors, etc. that go into them.

The Vickers Unit is designed and built with the "know-how" obtained during more than a quarter century of experience in practically every kind of hydraulic operation, plus a thorough understanding of your needs. It is built exactly to your individual requirements. All necessary pumps, valves, intermediate piping, oil reservoir, motors, controls, etc., are in one compact and self-contained "package". It includes all needed hydraulic accessories such as oil filters, air cleaners, oil level gauges, fittings, etc. Hydraulic connections may be grouped in a conveniently located manifold.

The result is simplification of hydraulic design and important savings in installation and maintenance costs. Vickers undivided responsibility for the entire hydraulic control system is another important advantage to both the machine builder and his customer. • Write for new Bulletin 52-45.

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Machinery Hydraulics Division
ADMINISTRATIVE and ENGINEERING CENTER
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6053-R

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

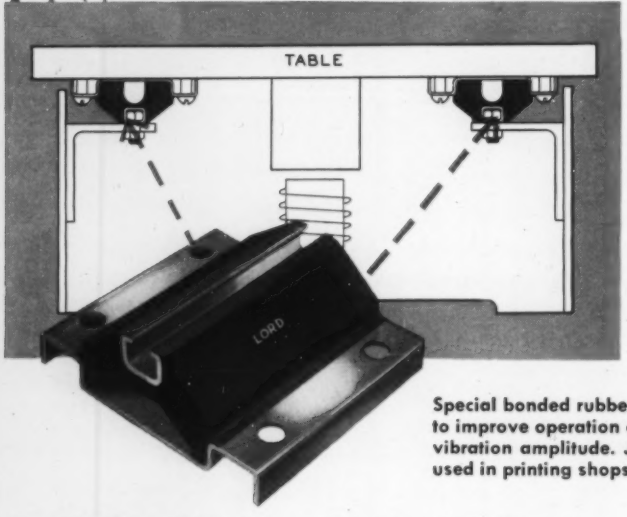
LORD puts vibration control to work!

gives paper jogger greater amplitude with less power input

Vibration, usually an undesirable effect to be minimized, can also be converted into useful work. This requires precise control for maximum effectiveness.

An example of this is the electromagnetic pulsations used by the Syntron Company on its PJ-15 and CPJ-15 Paper Joggers. LORD bonded rubber channel mountings control these vibrations, increasing their amplitude and producing more effective operation with less power consumption.

To provide uniform table motion and give the desired amplitude at the required frequency, the dynamic stiffness of the two LORD mountings must be closely controlled. These mountings, designed and produced to meet Syntron's strict requirements, are typical of the results when LORD engineering is applied to your vibration problem. LORD's experience in Engineered Vibration Control and Bonded Rubber Products is unsurpassed. Contact your nearest LORD Field Engineer or the Home Office, Erie, Pennsylvania.



Special bonded rubber mounting (left) was Lord engineered to improve operation of Syntron Paper Jogger by increasing vibration amplitude. Jogger vibrates at 3600 c.p.m. and is used in printing shops and binderies to increase production.

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LORD MANUFACTURING COMPANY • ERIE, PENNSYLVANIA

LORD BONDED RUBBER

designers and producers of bonded rubber products since 1924

Circle 451 on page 19

(Advertisement)

New stop clock designed for accuracy, versatility

Today's product designer, control systems engineer, nuclear physicist, and graphic panel manufacturer have a common need—an instrument capable of measuring elapsed time to a hundredth of a second, with an accuracy better than 0.02 of 1%.

Wide field—wide requirements

But there the sameness ends—the nuclear physicist needs a hermetically sealed device for remote control; the product designer requires load switches and local pushbutton reset; the graphic panel man wants smart appearance. The lab technician wants a portable model. The military asks for the smallest unit consistent with reliable readings, while the sports event timekeeper must have a large dial.

How can you meet these diverse requirements? Well, here's the answer to that question—a product of Cramer's experience and knowledge of precision timing.

Accuracy for everybody

You select a small, powerful and inherently accurate drive motor, add a 110-tooth positive clutch and apply it on the high-speed shaft. Back it up with a potent relay. When the signal comes, the unit responds instantly, and we have *accuracy*.

All-electric operation for flexibility

Add heart cams on the mainshaft and a rugged solenoid to belt them home within 1/10 second after the reset switch is operated. Now we have *electrical reset*, either remote or local.

For *versatility*, provide for load switches with cams on fast or slow pointer shafts. Cut and set at the factory, cams will offer a variable number (and duration) of pulses per second or minute, or with load switches wired in series, the unit can be used as a highly precise time delay relay or interval timer.

Commercial or Mil-Spec housings

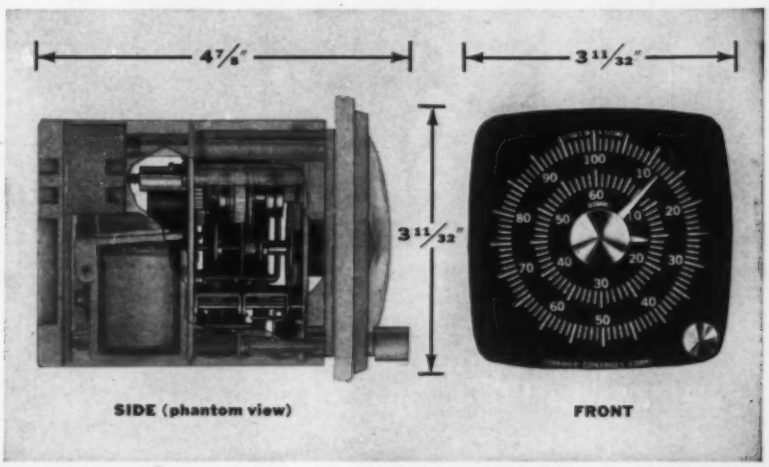
Now let's enclose the mechanism. Commercial housing is dust-tight and has a 12-place terminal block. Also developed: a militarized model to withstand high vibration, shock and severe environments. A deep-drawn solder-sealed enclosure with 14-pin glass-beaded header, evacuated and hermetically sealed will do it.

Dials, pointers—Loewy styled

What's left? The business end of things—dial and pointers. Let's tackle this for readability, and at the same time, shoot for eye-appeal. This time we'll go to the *styling* experts — famous industrial designers, Raymond Loewy Associates. They come up with the last word in human-engineered dial-pointer combination for fast, exact readings. Frame it with a pleasing bezel that can be finished to match or harmonize with your panels.

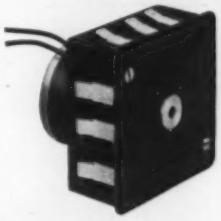
Now it looks like the precise instrument that it is—the new Cramer Type 691 Time Totalizer. Bulletin PB-691 tells more about it. Write for your copy today. The Cramer Controls Corp., Box 6, Centerbrook, Conn.

P.S. We've got the six-inch dial version and the portable model, too. 7.20

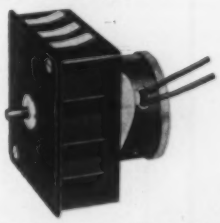


NEW time totalizer. Type 691 features instantaneous electrical reset, accuracy within 0.02 of 1%. Standard ranges: 60 seconds in 1/100 sec., 60 minutes in 1/100 min., and 60 minutes in seconds. Factory-set cam-operated load switches (rated at 5A, 250 vac, resistive) can be supplied. Available for standard voltages at 50, 60 cps; for 400 cps with d-c clutch; and for d-c voltages. Mechanical and electrical life in excess of 1-million operations.

TWO MORE NEW CRAMER PRODUCTS



NEW cycling timer. Type 571, ideal for "cycling" electrical equipment such as appliances, vending machines, advertising displays, at lowest possible cost. 1 to 4 poles. Speeds from 1 rpm to 1 revolution in 8 days with 30-amp contacts. Faster speeds with lighter contacts on special order.

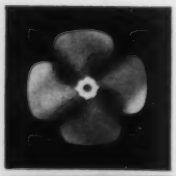


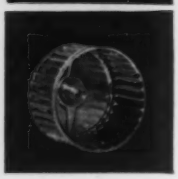
NEW interval timer. Type 271, for built-in applications. Provides an economical way of timing appliances, photo equipment, ovens, etc., for manually preset interval. 1 or 2 poles. Time ranges from 45 seconds to 6 days with 30-amp contacts. Normally furnished without knob or dial.

TALK IT OVER WITH

CRAMER CONTROLS
CORPORATION

Circle 452 on page 19





LINE OF LEAST RESISTANCE

Torrington now offers to manufacturers in the air conditioning, heating and ventilating industry the most complete line of air moving units in the world... and in the three basic areas of air impeller development: fans, airotors and complete blower units. Backed by the industry's finest research and development facilities, Torrington engineers work *only* on air moving problems and products. No matter what yours may be, try the line of least resistance: *Talk to Torrington!*

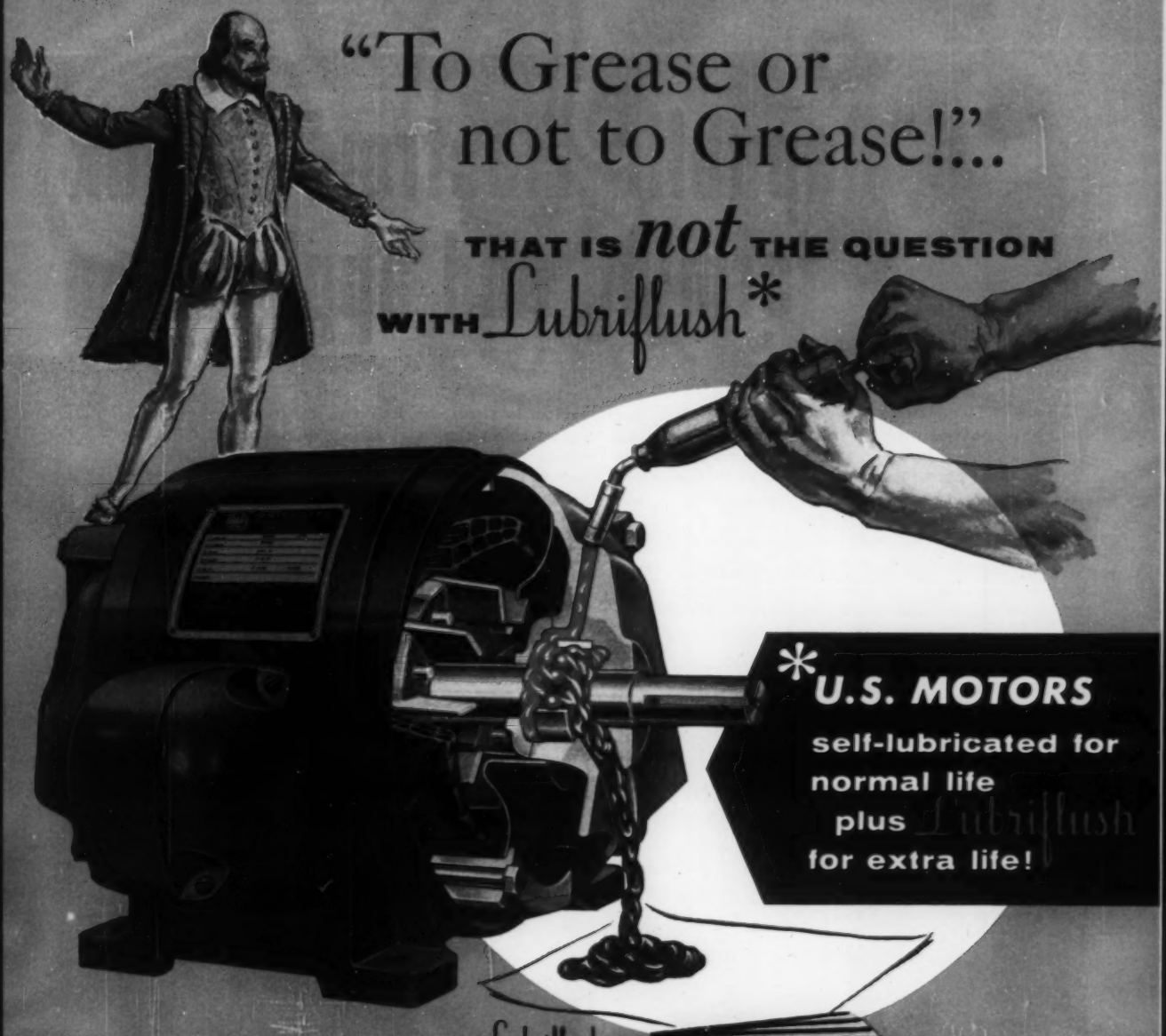
THE TORRINGTON MANUFACTURING COMPANY

TORRINGTON, CONNECTICUT • VAN NUYS, CALIFORNIA • OAKVILLE, ONTARIO

Circle 453 on page 19

"To Grease or not to Grease!"...

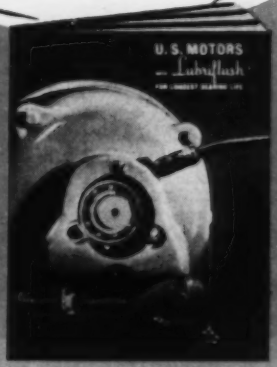
THAT IS *not* THE QUESTION WITH Lubriflush*



***U.S. MOTORS** self-lubricated for normal life plus Lubriflush for extra life!

MOTOR LIFE IS INCREASED WITH Lubriflush

Bearing failure, in most cases, is due to inadequate lubrication rather than inability to carry the load. With the exclusive Lubriflush system, U.S. motors give you extra advantages—convenient, thorough *transverse* re-lubrication. No longer is it necessary to tear down your motor to get at the bearings to do a re-greasing. Lubriflush directs transmission of new grease *transversely* from behind the bearing, through the ball race to the opposite side, expelling the old worn-out grease through the drain. In ordinary bearings, the new grease replenishes only one side of the bearing, failing to effect a complete re-greasing..



Free!

Get this 8-page full color booklet on Motor Lubrication

A real refresher course on motor lubrication. Tells all about motor bearing greasing. Fact-packed pages reveal engineering data that will amaze you. Send Coupon.

Circle 454 on page 19

U.S. Electrical MOTORS

MAIL COUPON NOW ▶

U. S. ELECTRICAL MOTORS Inc. MD-6
Box 2038, Los Angeles 54, Calif. or Milford, Conn.

☐ Send Lubriflush Booklet ☐ Send General Booklet

NAME _____

COMPANY _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

Mr. John S. Lea, Vice President, Kelley Manufacturing Company, Houston, Texas, reports:

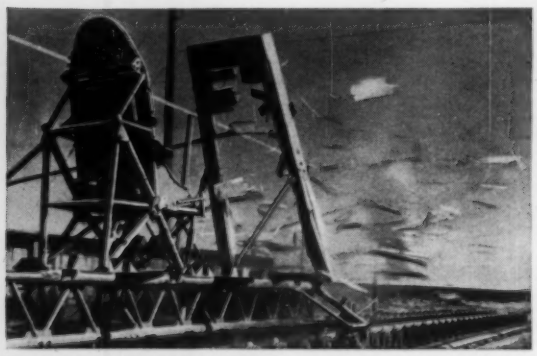
"Republic Electro Paintlok® forming and application

"Republic Electro Paintlok is the ideal material for one of our major product lines, acoustical fastening members," continues Mr. Lea. "Fabricating the sheet into H and Z members, splines, angles and couplers requires extreme forming and bending. We know from past experience that the special coating on Republic Electro Paintlok won't crack, flake or peel off no matter what we do. This means that after painting and installation, Kelley Acoustical Fastening Members provide our customers maximum satisfaction almost indefinitely, with little or no maintenance at all."

This example is typical of the improvement made possible in an endless variety of products through the use of Republic Electro Paintlok. In addition, this versatile sheet often allows substantial savings in production time and money because it is shipped from the mill in prime condition for painting. In many cases only the final finish need be applied to provide full protection and attractive appearance. Cleaning and priming may be eliminated.

Finally, the chemically treated zinc surface of Electro Paintlok retards corrosion even when scratched through, and effectively limits it to the point of damage.

Get all the facts on this versatile sheet steel product and how it can help solve your forming and application problems. Simply contact your Republic representative or mail coupon.



STRUCTURAL APPLICATION PROBLEMS requiring low weight plus high strength are best solved using tubular construction. A good example is this rocket sled designed to withstand extreme forces of abrupt deceleration. Republic ELECTRUNITE® Steel Mechanical Tubing is ideal for such an application. Uniform in wall thickness, concentricity, strength and ductility, it permits reduction in bulk without sacrifice of safety. Send coupon for data.

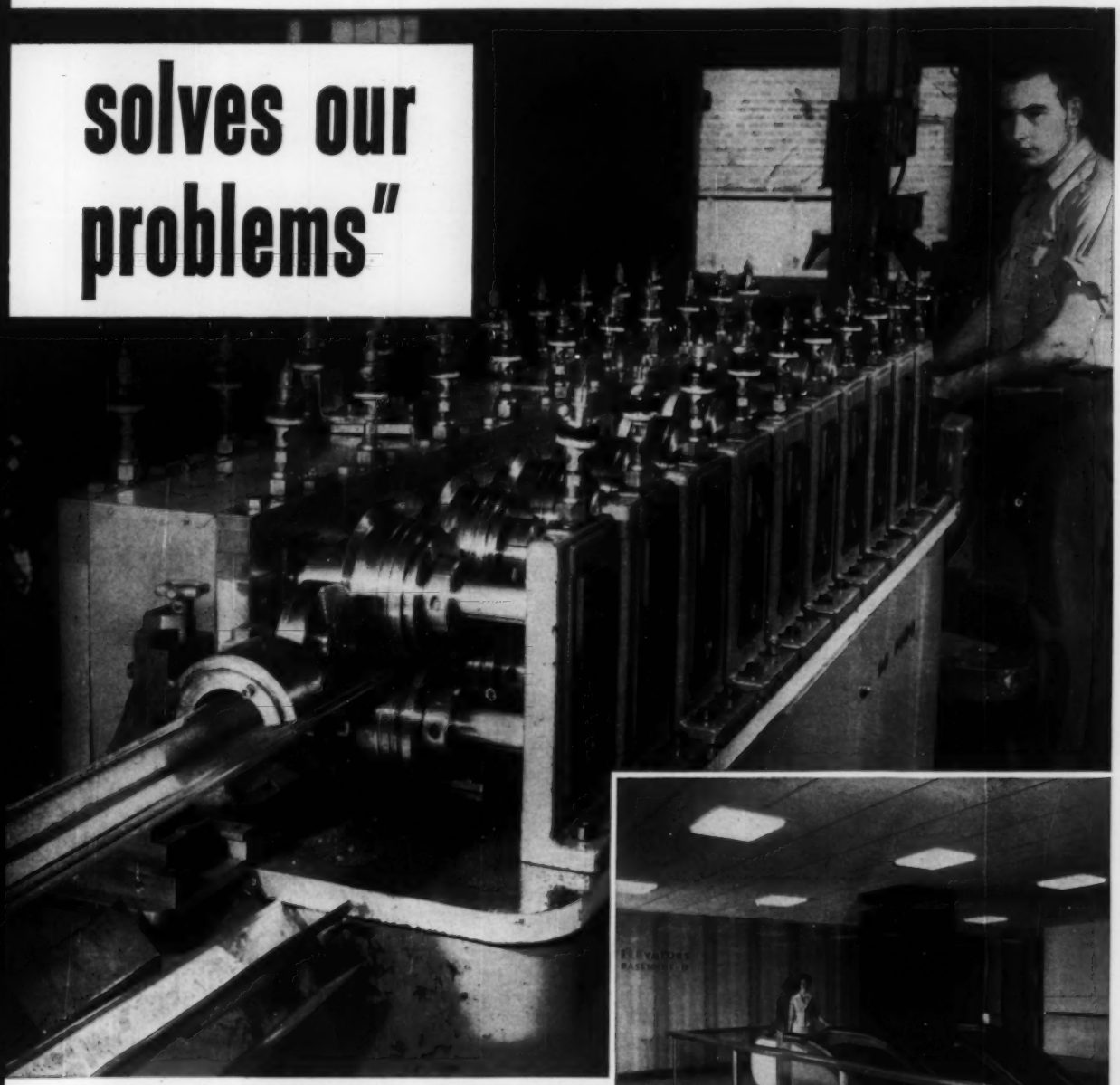
CORROSIVE APPLICATION PROBLEMS, like this coal-cleaning plant disc-type filter unit, demand the strength and corrosion resistance of Republic ENDURO® Stainless Steel. Here the stainless steel cloth used to cover disc segments is not only much more durable, but more than twice as efficient in recovering coal "fines" as the cotton cloth formerly used. To be sure of the best, specify ENDURO.

REPUBLIC

REPUBLIC STEEL

World's Widest Range of Standard Steels

solves our problems"



TYPICAL APPLICATION of Kelley Acoustical Fastening Members is shown in the ceiling at right. Base metal is Republic Electro Paintlok. Its special coated surface grips paint tightly, assuring years of maintenance-free good looks. Even severe forming, like the operation shown above, has no effect on its outstanding paint-holding characteristics. Coating will not crack, flake or peel off.

STEEL

and Steel Products

REPUBLIC STEEL CORPORATION
Dept. C-3071
3130 East 45th Street
Cleveland 27, Ohio

Please send me more information on:
☐ Electro Paintlok ☐ ENDURO Stainless Steel
☐ ELECTRUNITE Mechanical Tubing

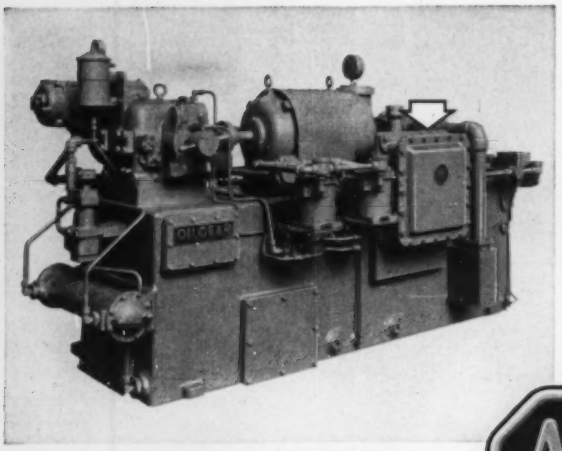
Name_____ Title_____

Company_____

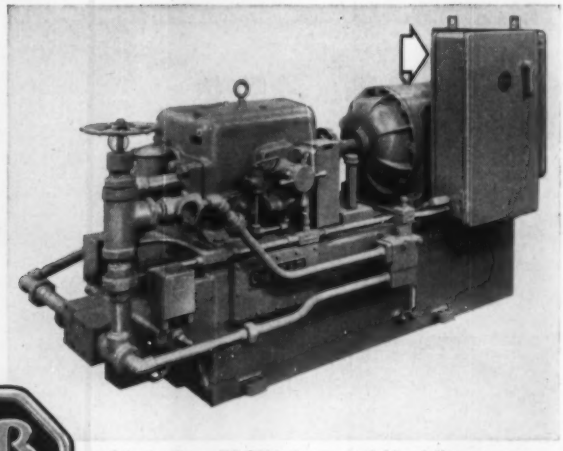
Address_____

City_____ Zone____ State_____

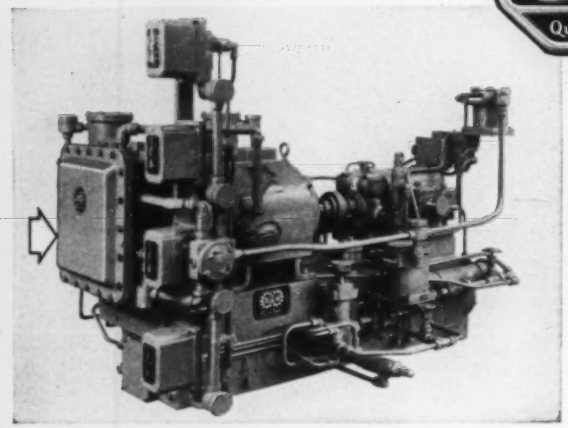
Circle 455 on page 19



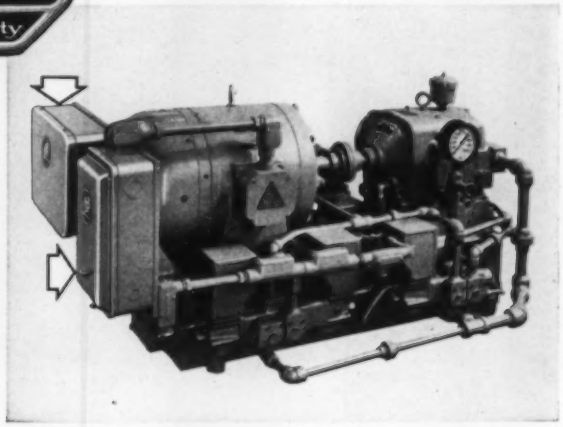
Oilgear Type DXE-825 2-way variable delivery pump for large Cordite press. Allen-Bradley motor controls in Type 7 explosion-proof bolted enclosure.



Oilgear Type DR-3511 1-way variable delivery pump for fluid power to gun gymnasticater. Allen-Bradley motor controls in Type 1 general-purpose enclosure.



Oilgear Type DXG-425 duplex pump for fluid power to large Cordite extrusion press. Allen-Bradley motor controls in Type 7 explosion-proof bolted enclosure.



Oilgear Type DS-825 1-way variable delivery pump for fluid power to machine tool. Allen-Bradley motor controls mounted in Type 1 general-purpose enclosure.

OILGEAR FLUID POWER PUMPS ...use Allen-Bradley Motor Controls

The four powerful oil pumps shown above, and built by The Oilgear Company for delivering fluid power to large extrusion presses and other hydraulic machinery, are factory-equipped with Allen-Bradley solenoid motor starters. The enclosures used are determined by the conditions existing where the pumps are installed.

Why is Allen-Bradley control so popular with machinery builders? The answer is found in the solenoid design. Its one moving part is a virtual guarantee of millions of trouble free operations.

In addition, the double break, silver alloy contacts—used throughout the Allen-Bradley line—eliminate all need of maintaining contacts—they are always in perfect operating condition. Where bolted enclosures are used, maintaining contacts becomes a costly, time-robbing job.

Another outstanding advantage is the protection afforded by the accurate and reliable overload relays. Being solder pot relays, they do not deteriorate with age —they remain accurate and reliable.

Send for a copy of the Allen-Bradley Handy Catalog . . . a good reference manual on motor controls . . . manual and automatic. Write for your copy, today.

Bulletin 700 relay for machine tools.

Bulletin 709 solenoid starter removed from enclosure to show arc hood and two overload relays. Available up to 300 hp, 220 v; 600 hp, 440-550 v.

Allen-Bradley Co.
1333 S. First St.
Milwaukee 4, Wis.

ALLEN-BRADLEY
SOLENOID MOTOR CONTROL
QUALITY

In Canada—
Allen Bradley Canada Ltd.
Galt, Ont.

Circle 456 on page 19

June 27, 1957

Tranquility or Discontent?

A NOVEL proposal for peacefully subduing an enemy is to blanket his country with tranquilizing drugs; then he no longer cares about conquest. The implication that tranquilizers could be an effective weapon should serve as a warning against over-tranquilizing ourselves.

The spirit which inspires aggression is the same human drive which has produced every worthwhile advancement. It is motivated by the hope of reward. It thrives on discontent and languishes in tranquility.

Reward, broadly, encompasses such factors as inner satisfaction, social prestige, personal power, and financial gain. Fortunately for mankind there have always been enough engineers for whom inner satisfaction represents high incentive.

But opportunities for individual achievement and the unique satisfaction it engenders are likely to diminish with the increasing complexity of engineering and the consequent emphasis on teamwork. In a sense, the spreading of effort and recognition could have a tranquilizing effect unless team spirit can be kept at high pitch.

Current efforts to raise the social and economic status of all engineers are highly commendable. But it would be dangerous to lose sight of the equal need to maintain sizable differentials to permit recognition of outstanding individual achievement.

Otherwise, engineers may be tempted to relax in the tranquilizing atmosphere of a team with adequate status, and to produce no better than adequate performance. We need better than adequate engineering performance to stay ahead: "Oh the little more, and how much it is; the little less, what worlds away."

Colin Carmichael

EDITOR

A practical approach for

Reducing Drafting Costs

IF drafting be the end product, simplified drafting practices would be the answer to optimum results. But just what is drafting? Basically, perhaps, it is simply the creation of drawings which are instructions, or communications, to the shop. These communications are the sum of many others—design, engineering, management, tooling, etc. Between initial proposal and end product is a long chain of interrelated communications. Each link of this chain has an input and output.

However, when the engineering department is considered as a chain of separate but interrelated blocks of communication units, it will be found that the drafting section is the block with least freedom. It does not have nearly the latitude of decision, if any, as engineering, design, production and other operations. Its primary function is to translate, without change, the decisions of other departments. Drafting is the only department which usually must rely completely on the information provided from outside.

It is apparent, then, that reduction of drafting cost cannot be considered as a problem separate from other engineering functions which have to feed information to drafting. To reduce drafting cost, which means more work in less time, requires increased efficiency. But it is futile to increase efficiency of output if input is erratic. Like any communications system, when the input is poor the product of the amplified output is an unharmonious result.

Thus, the saving of drafting time must start with the organization of the flow of information to drafting necessary for its function.

Forms of Communication: First step in the process is the project or engineering specification. Its purpose is to clarify the requirements of the project and to instruct and guide design and engineering forces in objective and constructive thinking on all phases of the problem. Only when the problem and its requirements are completely understood should the engineering work begin.

Engineering communications are block diagrams, sketches and electrical, hydraulic, and mechanical schematics. All of this information should be on some kind of company format so that a number can be assigned to it. Then this information can be filed as a job record or even used as original drawings without redrafting. Development of details of design should not start until engineering decisions have been made on how the problem will be solved.

When the solution is ready for job assignment, a design specification should be written. Its purpose: To furnish designers and draftsmen, at the inception of design, data necessary to unify design features and to avoid or reduce subsequent search for information. In the design specification, the possible questions from designers and draftsmen are answered in advance!

In scope, this specification is a detailed statement on desirable design features such as: Dates of specifications and standards to which the design must conform; type of materials to be used in general or for special parts; type of enclosures; gasketing; human engineering considerations; finishes; shock and vibration requirements; weight factors; classes of gear precision; type of drawings; lubrication; manufacturing methods; etc. It may contain a portion or a digest of information provided in the project or engineering specifications.

The communication from the designer is a layout. Wherever possible, drafting should not start before the layout is completed and approved. The layout should show all significant dimensions, such as: distances between bearing shoulders, end play on shafts, critical materials and heat treatment for special parts, and any other information which has been derived as a result of work on the layout. Only if communications between departments is organized, can the drafting section be expected to produce drawings of desired quality in minimum time.

Fundamental Concepts: A basic point to remember is that a complete drawing is composed of two parts:

1. Engineering information.
2. Geometrical representation of the part, or pencil pushing-stage.

To reduce drafting time, no time should be spent by draftsmen in waiting for engineering information or clarification, or in independent research.

Another important concept in cost reduction is that the greatest saving of drafting time is to

. . . recommendations on how to cut drawing time and effort in engineering operations

By Rowen Glie

Supervisor of Standards
W. L. Maxson Corp.
New York

eliminate drawings completely. This requires consideration first of what kind of parts should be drawn up. In general, these parts can be subdivided into two classes:

1. Parts of general use which are used over and over again. To this, perhaps, could be added all purchased parts since any such parts could, generally, be used over again.
2. Special parts which can be used on one job only; castings, covers, etc.

The standards department of a company can provide tremendous savings of drafting time by drawing beforehand all parts of general use, having great probability of reuse on many projects.

Drawings of bearings, instrument shafts, dowel pins, collars, capacitors, resistors, etc., should be a combination of tables, code designations or dash numbers. In this way, a tremendous number of variables of these parts can be taken care of with one drawing.

A practical approach that has been successfully used in the development of part standards to reduce drafting time is outlined in *Typical Parts Standards System.*

Consider, for example, certain types of electronic equipment where most of the parts in the design, common or standard, are purchased. Here, the savings realized by having the parts drawn in advance are obvious. In fact, it is not always necessary to make drawings for these purposes. Frequently, standard AN drawings or other national or government specifications can be used. In any event, the objective is the same: eliminate drawings whenever possible.

Drafting Alternatives: Despite initial costs, advance drawings are a sure method of cost reduction. But what about drafting of special parts? Here, there are three alternatives to consider:

1. Standard drafting practices as outlined in American Standard *ASA—Z14.1-1946* or Joint Army-Navy Standard *JAN-STD-1.*
2. Free-hand sketches.
3. Simplified drafting practices.

STANDARD DRAFTING PRACTICES: Very little can be done to reduce cost of standard practices. They are well organized. However, it is interesting to note that many of the techniques associated with simplified practice were anticipated in the *JAN* standard.

FREE-HAND SKETCHING: Experiments were conducted with free-hand sketching to evaluate its potential as a cost reduction method. Here are the results. On very simple parts, the time saved was 50 per cent. On slightly more complicated parts, the saving was 35 per cent. On complex parts, free-hand sketches could not be used at all. For example, a complicated casting would be impossible with this technique.

Another handicap of free-hand sketching is the lightness of lines. They are never "engraved" as scale drawings often are. They cannot stand the repeated reproductions necessary on production jobs.

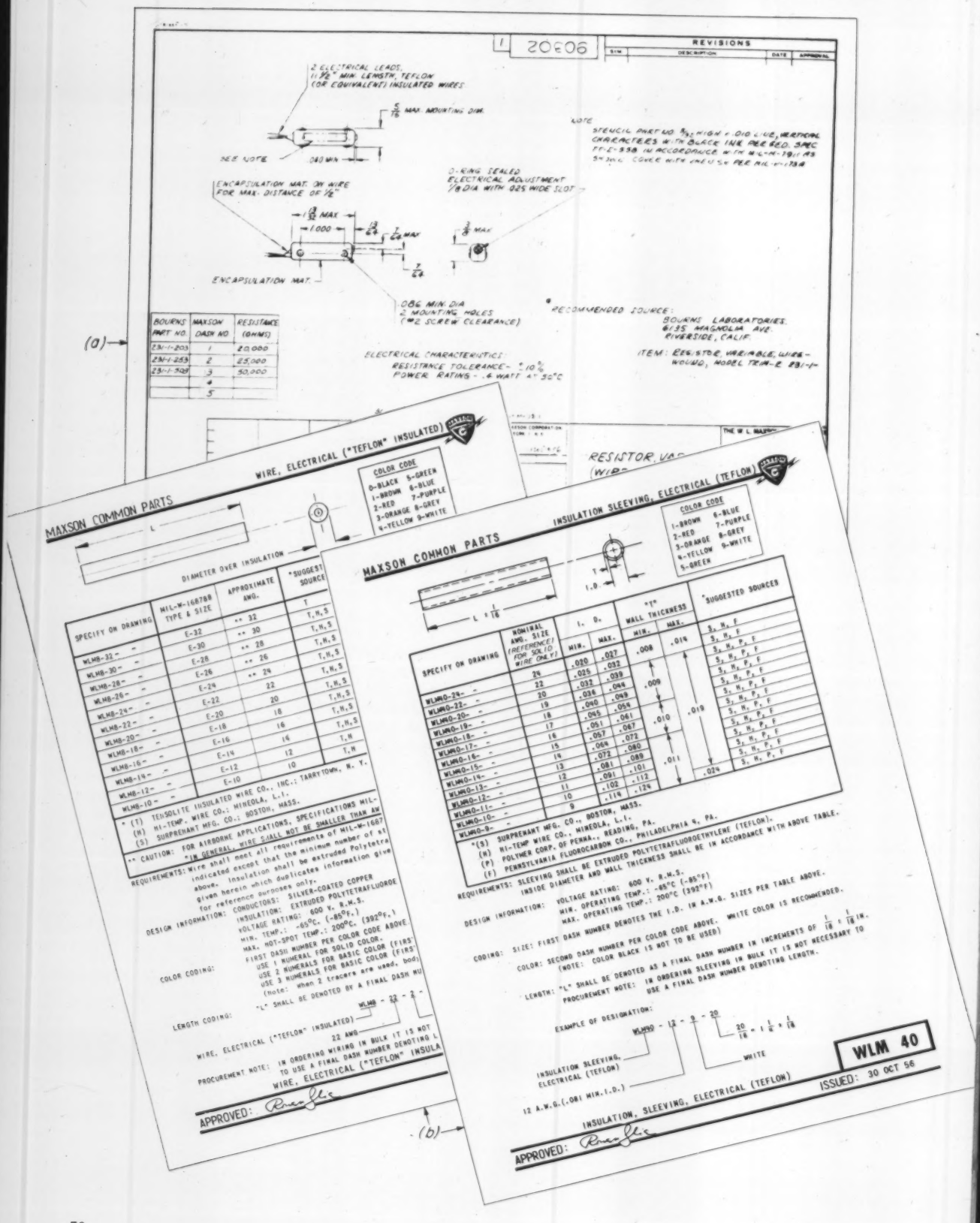
One other important factor must also be taken into consideration. When a designer makes his own details to scale, he goes through a complex psychological process. He analyzes his own design anew and rechecks it. During the detailing, the flaws of the design become more obvious. Complexity of machining, cost of purchased part, dimensional or fit-and-tolerance problems are reconsidered. A reappraisal of strength considerations may appear to be necessary, such as the need for more strengthening ribs on a casting.

It is a known fact that many designers often find it necessary to change the layout during detailing. "Scale detailing" by the designer is more than a detailing of parts, it is an additional creative effort that benefits the design. When detailing is done by a draftsman, the psychological process is the same; however, greater emphasis is placed on dimensional checking.

The role of free-hand sketching in drafting can, perhaps be best summarized as follows:

1. With free-hand sketching, the advantage of re-evaluation of the merit of the design that accompanies detailing is lost. Free-hand sketches have a great "error probability." They reproduce poorly and their life is short.
2. Considerable reliance must be placed on the draftsman's ability to evaluate, interpret and translate the information from the layout to the drawing.
3. Draftsmen must be trained to do free-hand sketches. But even with adequate training not all draftsmen will be good free-hand artists. Cross-sectioned underlays will help but will slow up drafting. To work fast the draftsman must have the same gift of "sense of proportion" as an artist making a man's portrait. In the same way that a machinist, who is not a sculptor, is perfectly able to translate

Typical Parts Standards System . .



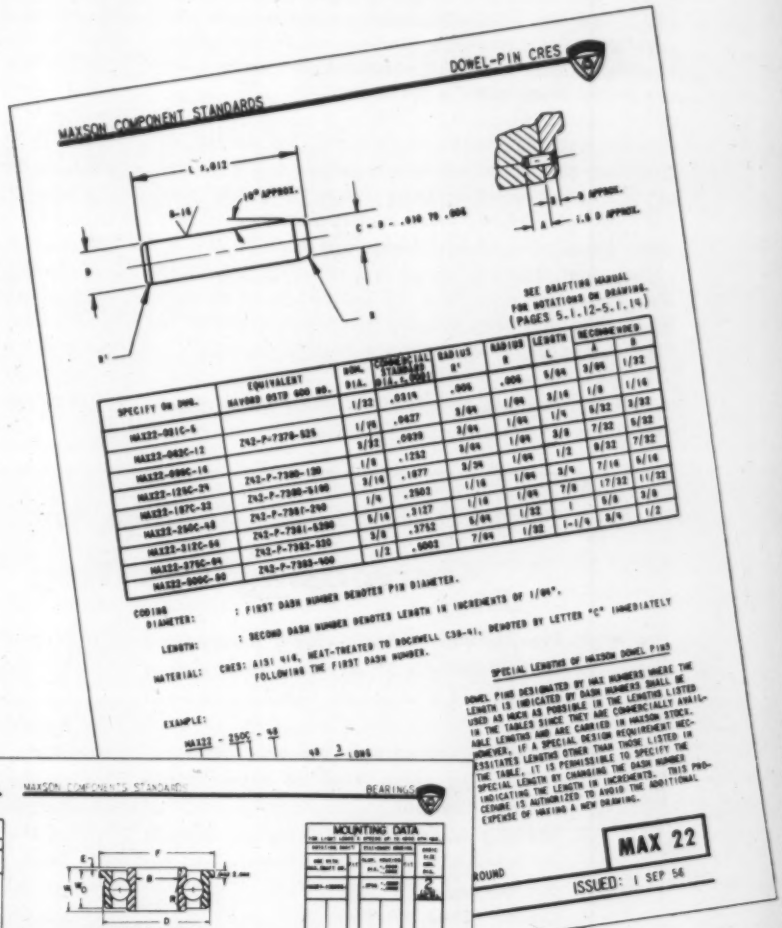
At W. L. Maxson Corp. all purchase drawings have a 90,000 series number, (*a*). They are tabulated whenever possible. The 90,000 series drawings which are to be recommended for use over again are marked "Common Parts."

In the standards department, the drawings with highest probability of reuse are redrawn on special format and designated by the prefix "WLM," (*b*). On WLM Common Parts drawings engineering information is added. This information assists the designer in selection of parts by giving, for instance, limitation of use, temperature ranges, and so on.

Besides Common Parts, in 90,000 series and WLM's, there also are "Standard Parts" which are designated by the prefix "MAX," (*c*).

All Common Parts are recommended for use. All Standard Parts are mandatory for use. The MAX and WLM parts are usually kept in stock.

On all of these drawings, the quality of information is always high. It is checked and rechecked continually. Drafting techniques are strictly to "old-fashioned" standards. Only universally accepted techniques are used. These drawings are furnished to nonengineering as well as engineering personnel and reliance cannot be placed on the technical level at which the drawings will be used.



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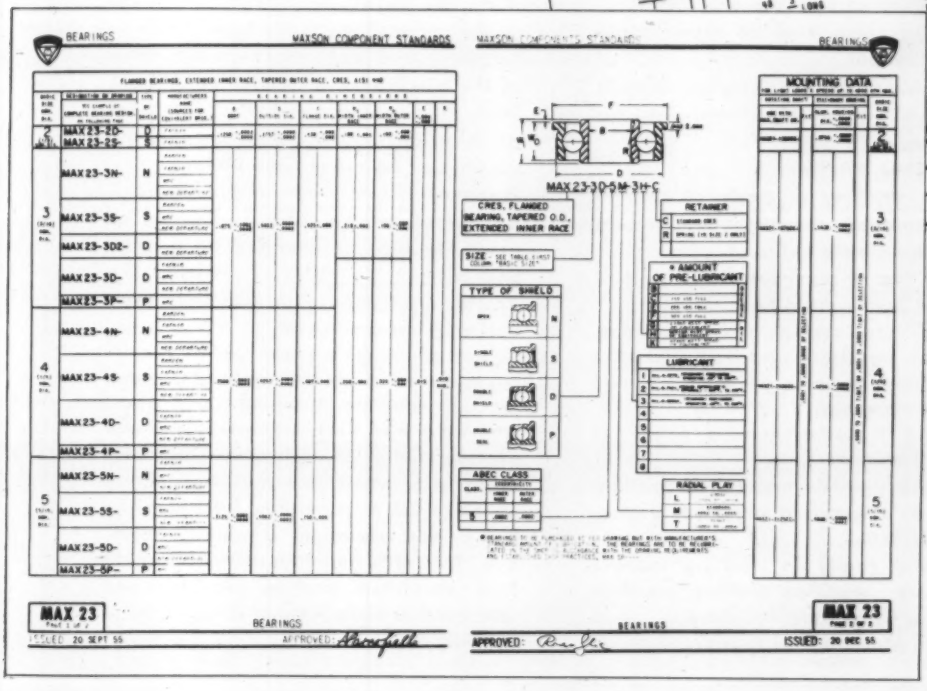

a two-dimensional drawing into a three-dimensional piece, so it is with the draftsman. He can draw but he is not expected to be an artist. The draftsman has a synthetic ability, the free-hand sketcher has an artistic ability. The two gifts are different and rarely combined in one person.

4. Free-hand sketching has its place. It can be used on: (1) parts of very simple outline, (2) parts having few dimension lines, (3) block diagrams and schematics, (4) outline drawings where the main purpose is to show mounting dimensions, and (5) small assemblies. But free-hand sketching has limited use unless combined with "to-scale" drafting.

SIMPLIFIED DRAFTING PRACTICE: The subject of drafting simplification has received a great deal of attention recently. In a large part, the controversy now raging over such practices can perhaps be attributed to overzealous promotion.

But just what is simplified drafting practice? For convenience, it will be defined here as any method of drafting simplification not included in the standards mentioned previously, particularly *JAN-STD-1*.

A basic problem is how to evaluate the savings provided by simplified practices. Many claims of cost savings have been made and they all are undoubtedly true. But this does not mean all drafting operations will realize the same benefits.

In most cases, savings provided by simplified drafting practices will be a total of small and large savings on each drawing. In the author's opinion about 20 per cent of drafting time could be saved by using such practices. But the fact that savings will vary from drawing to drawing means that time spent by draftsmen using simplified drafting techniques must be carefully controlled. Otherwise the whole result of the trouble taken to introduce new techniques will be loss of drafting efficiency.

Under adequate control, simplified drafting practices can reduce drafting time, and consequently the cost of drafting.

The biggest question is: Which of many simplified drafting practices should be used? This is a problem that in the final analysis each company will have to solve for itself.

As pointed out previously, a drawing is a communication. The content and the quality of com-

16 Steps for
Increasing Drafting Efficiency

1. Provide the mechanics for a steady flow of information to drafting by creating project and design specifications for each job.
2. Require engineers to present communications on some kind of reproducible company format.
3. Make it mandatory for designers to mark up layouts with all significant data for draftsmen.
4. Create "Shop Practices."
5. Eliminate drafting of parts of general use by creating drawings of standard and common parts.
6. Create a file of purchase drawings and means of their control by:
   a. Establishing special rules for tables, code designations and dash numbers.
   b. Requiring periodic revision of purchase drawings.
   c. Making a comprehensive index of such drawings.
7. Codify the simplest method of drafting described in standard practices, preferably *JAN-STD-1*.
8. Select and codify in drafting manual form those simplified drafting practices which are acceptable. Practices in use at American Machine and Foundry, General Electric or International Harvester could be the basis for such selection. (See Bibliography at end of article.)
9. Simplify drawing change procedures.
10. Study the possibility of making details on the same sheet as the assembly.
11. Put the list of parts on the same sheet as the assemblies whenever possible.
12. Study the use of photographic techniques as a means of recording breadboard assemblies, harnesses and pipings.
13. Recommend wider use of photographic recomposition when only portions of an assembly must be changed for another project.
14. Provide draftsmen with adequate tools and working conditions.
15. Control drafting time and cost by requiring a record of time spent by draftsmen on each drawing. This will permit realistic time and cost estimates and will provide control of draftsmen's activities.
16. Create a cost and time-conscious atmosphere in all departments, by organization of cost control as a primary objective. This will permit maximum benefit from simplified drafting practices and will increase the efficiency in any type of drafting.

munication depend on the number and level of its recipients. When only the company's experimental laboratory is involved, the simplification can be extreme. When production is involved, with drawings going out to purchasing, vendors, tool makers, methods engineers, maintenance men, military inspectors, company inspectors, etc., the problem is different. Here is one rule that may serve as a practical basis for solution:

> Whatever is the simplification, the drawing must be understood by anybody with standard technical experience in engineering, design or shop operations without engineering help. Not revolution, but evolution. When methods of simplification are selected and agreed to by engineering, design, drafting and shop personnel, a definite standard should be established. It must be possible to specify costs and time required to make the same drawing by simplified or by standard methods. In other words, a price tag should be attached to each method of drafting.

Other Cost Factors: There are a few more items to be considered in reducing drafting cost:

DRAWING CHANGE PROCEDURES: Often, because of undue complication of drawing change procedures, cost of a change on a drawing may be ten times that of the original drawing. On research and development projects, when the changes may involve a major percentage, if not all, of the original drawings, unduly complicated procedures can be a very costly luxury.

SHOP PRACTICES: These are specifications for a minimum quality of workmanship when information is omitted on the drawing by negligence or by reliance on "good commercial practice."

For instance, unless the part is critical, such notation as straightness of an instrument shaft will not be indicated on the drawing. Now, if the part goes to a vendor, the questions are: How straight is straight, how right is the right angle? In one case, a 2 in. diameter gear was supplied by the vendor with 1/16-in. wobble. When asked "Is it good commercial practice?" he answered, "Why not! This is *our* good commercial practice."

Any information given on the drawing supersedes the corresponding information given in shop practices. But if the information is not given on the drawing, shop practices will save redrawing time for drawing changes.

COST-CONSCIOUS ATMOSPHERE: Probably the most important factor in reduction of drafting time is a cost and time-conscious atmosphere in the engineering department. Unless cost reduction is made a primary objective in all departments which form the communication chain discussed previously, time cannot be saved in the drafting section.

Suggested steps for increasing efficiency of drafting operations are summarized in *Increasing Drafting Efficiency*.

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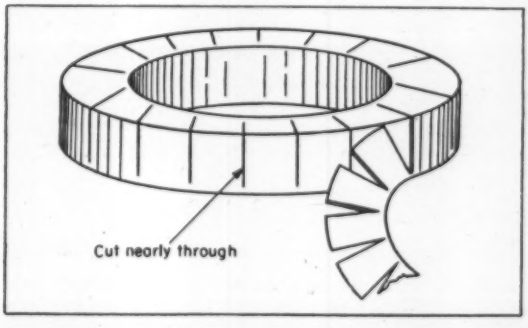
Tips and Techniques

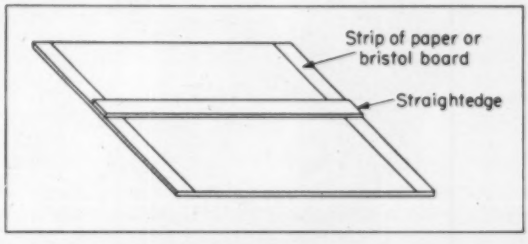
Simplified Tape Application

When applying drafting or masking tape to the corners of paper on the drafting board, tearing it from the roll usually results in odd-length pieces and wasted tape. The job can be speeded and less tape used if the entire roll is cut into segments before using. A sharp knife or razor blade is used, leaving a narrow link between segments.—PHILIP E. MCCAFFERTY, *Stanwood, Iowa.*

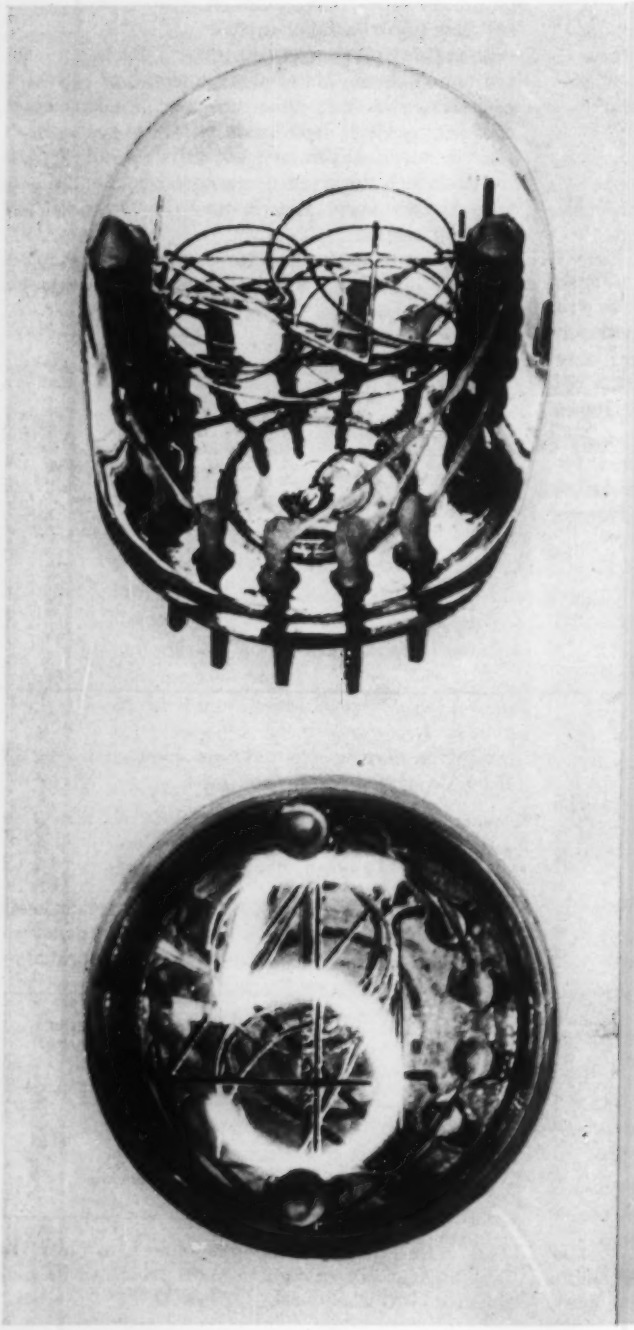


Keeping Drawings Clean

One way to keep straightedges from smearing drawings is to place a strip of heavy paper or bristol board under each end of the straightedge. This raises the straightedges enough to clear the drawing but not enough to allow triangles to slide under it.—RICHARD MARSH, *Lima, O.*



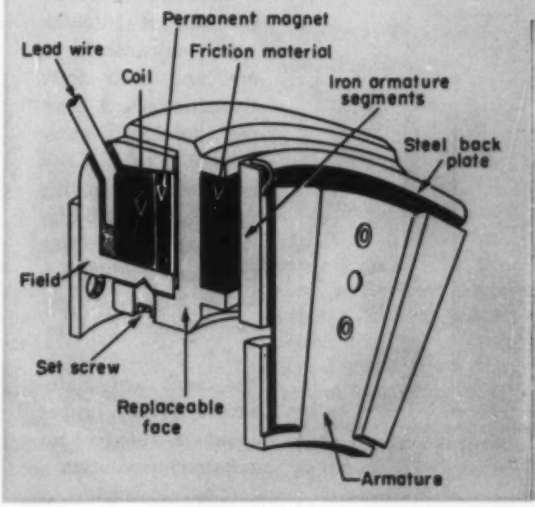
scanning the field for *ideas*

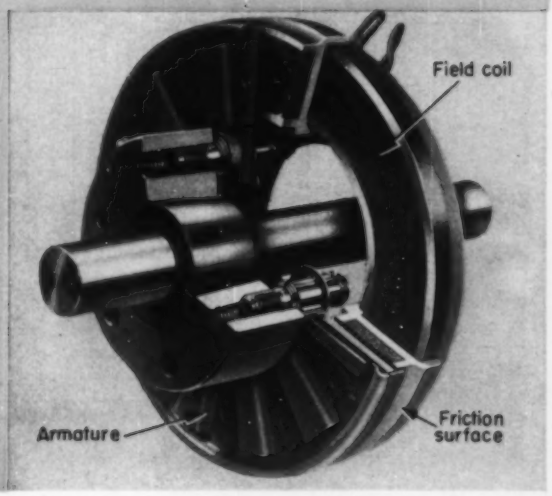


Stacked cathode elements convert electronic signals directly into readable characters in a novel read-out tube construction. Developed by the Electronic Tube Div. of Burroughs Corp., the Nixie read-out tube contains stamped cathodes in the form of digits, all occupying a common viewing area. Individual cathodes are triggered by a base-switching tube, or similar voltage source, to cause a specific numeral to glow.

Helical tracks on heavy-duty wheel rim facilitate axial shifting of relationship between wheel and rim. Employed on International Harvester tractors, the design provides a wide tread-width adjustment without removing the wheels. The rim is centered on the wheel and locked concentrically by four jack screws that ride on the rim tracks. Accidental axial shifting of the rim under load is prevented by clamps that secure the jack screws to the rim track. Removal of the clamps and loosening of the jack screws permit adjustment of the tread width by braking one wheel and engaging the drive clutch to rotate one wheel, along the helical tracks, relative to the rim.

Dual-magnet design of electric brake assures fail-safe operation in case of power failure. Basic operating elements of the Warner Power-Safe electric brake consist of a rotating armature and a stationary field coil with a removable friction surface. A ring of permanent magnets is imbedded in the face of the stationary field. With the power on, the brake operation is controlled by electromagnetic action of the field coil. In event of power failure, the permanent magnets take over to stop and hold the load until power is restored. The flux path in the power-off condition is concentrated through the armature because the field shell, which offers the only alternate flux path, has a higher reluctance or resistance.





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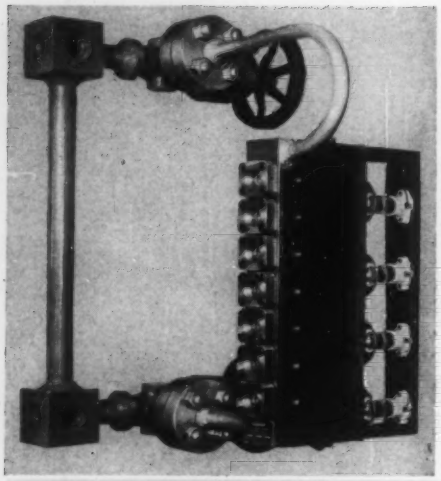
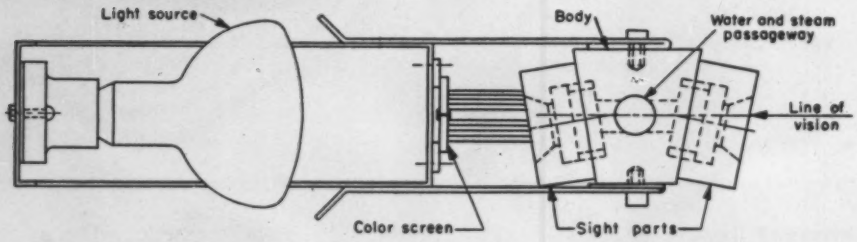
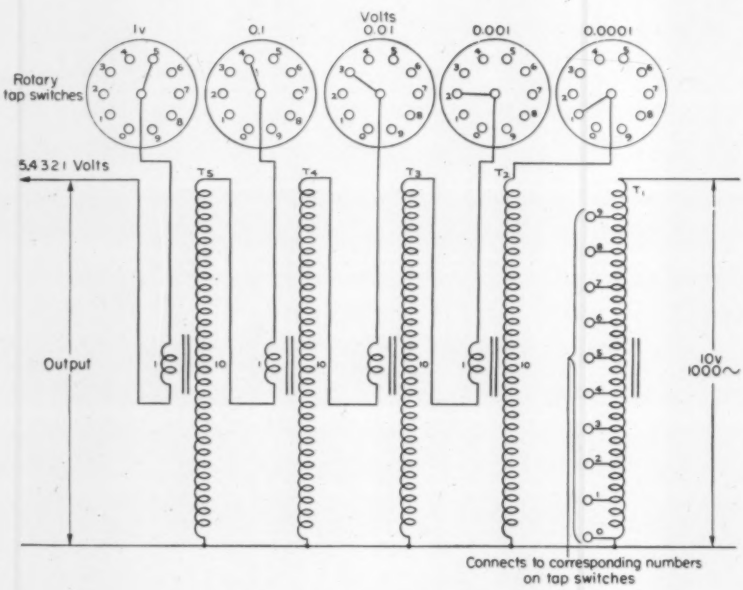


Refracted light beams are utilized to indicate fluid level in a visual-gage design. Developed by Yarnall-Waring Co., the Yarway Color-Port boiler-water gage indicates water or steam by a green or red color seen at the viewing ports. The gage consists of a body with the water-steam passageway, a two-color screen, a light source, and two vertical rows of sight ports which are set at opposite angles to the line of sight through the gage.

Light beams from the light source pass through the color screen which has two vertical color panels, one red and one green. When steam is present at the level of a sight port, the line of vision is undeflected and the red color is seen. However, water in the passageway deflects the line of vision to make the green color visible. Water level within the gage is thus indicated by the point of demarkation between red and green colors along the vertical row of sight ports.



Ultraprecise voltage resolution is achieved with a voltage-adding circuit in an analog control system developed by Cincinnati Milling Machine Co. Precision of one part in 100,000 is obtained by a combination of toroidal-type autotransformers and step-down transformers. A master toroidal transformer acts as a reference, supplying voltages for each digit to the other four transformers. The relative impedance ratios of output to input from one stage to the next are maintained at the proper point to supply the required resolution.



In the eyes of the law, there can be but one contract. Changing the terms of this contract involves certain hazards and can often lead to misunderstanding and controversy. Court viewpoints and pitfalls to be avoided in contract modifications are reviewed here.

Modification of Employment Contracts

By Albert Woodruff Gray
Forest Hills, New York

AS THE courts view it, an employment contract is no ordinary agreement. This fact was clearly established by a decision of the United States Supreme Court[1] many years ago when it ruled that such contracts are not transferable. In the words of the court, "You have the right to the benefit you anticipate from the character, credit and substance of the party with whom you contract."

This exclusion of personal service contracts from a transfer by assignment was one time paraphrased by Justice Holmes: "Service is like marriage which in the old law was a species of it. It may be repeated but substitution is unknown."[2]

When there is a change in the terms or substance of an employment contract, the comment of Justice Holmes still applies—there can be but one contract.

Oral Promises

Where the original employment contract has been oral and later the agreement is changed and

[1]References are tabulated at end of article

the contract reduced to writing, the terms of the oral contract are gone.

In a California suit[3], an employee was denied recovery of $28,617.39 claimed under an oral promise for what the employee termed "incentive pay" over and above a weekly salary specified in a written employment agreement. The agreement made no reference to, nor provision for, additional compensation. In denying the employee recovery under the provision of oral agreement made before or at the time the written contract was executed, the California court said:

"The employee was 'fenced in' on his only written contract with his employer. He never abandoned it or sought its revision. All such conversations are merged in the writing. By no asserted event or conversation occurring after the execution of the contract was it altered or modified.

"The written instrument and oral agreement, if there was one, eventuated from the same previous negotiations and cover the same subject matter. The result was an integrated agreement to which the parol evidence concerning such documents would apply."

This rule of law is now embodied in a statute of that state which reads: "When the terms of an agreement have been reduced to writing by the parties, it is to be considered as containing all those terms and, therefore, there can be between the parties and their representatives or successors in interest, no evidence of the terms of the agreement other than the contents of the writing."

Modified Or New Contract

When the original contract is in writing, however, and the modifications or changes are made *after* the execution of the written agreement, a controversy may occur as to whether the oral agreement made after the contract was written was a modification and change of the original written contract, or an entirely new agreement replacing the one in writing.

After a written contract for services had been made by an engineer, it was found that further preparation of plans and specifications was necessary. The engineer maintained later, in a controversy over his compensation, that his original employment agreement had been modified and additional compensation provided for the performance of extra work.

The employer contended that the written agreement had been entirely abandoned, and a new oral agreement made in its place under which the provisions for compensation had been fully met. The Oklahoma Supreme Court[4], affirming a judgment of denial of recovery, said of the situation:

"It is claimed by the employer that the written contract was abrogated and superseded by an oral contract and that under the terms of the new contract he did not owe the engineer anything. It is of course axiomatic that the parties to an existing contract may subsequently enter into a valid agreement to extinguish, rescind or modify the former contract but, as with any other agreement, the contract to rescind must be by mutual consent of the parties."

Temporary Agreements

A similar situation was brought before a California appelate court recently for review. Both this and the Oklahoma case emphasize the advantages for employer and employee of avoiding the pitfalls attending either oral employment contracts or oral modifications of written contracts.

An engineer had been employed for one year at $100 per week in addition to 30 per cent of the net profits derived from the business during the year. The employer further stipulated: "It is agreed that in the event you continue in my employ after December 31, 1951, it shall be at a salary of $100 a week plus only such amounts as may hereafter mutually be agreed upon in writing."

At the expiration of the year, the engineer continued in this employment assured by the employer that the agreement would be renewed and that the engineer would have a share in the profits. Several weeks after the expiration of the agreement, the employer had said to him: "I would like to change the setup and possibly put you on a salary basis and the bonus arrangement or something more definite." Further, the employer stated that profit-sharing was unsatisfactory because of renegotiated contracts and uncertainty of profits.

In its decision that the written agreement had expired and that the engineer's compensation was payable under a subsequent oral contract founded on this assurance of the employer, the California Supreme Court said:[5]

"It is not uncommon, however, for parties to make an oral agreement with the intention to reduce it to writing or supersede it by a new written contract. In such cases, whether they intend their oral agreement to be immediately effective or only to become binding on the execution of the writing, is ordinarily a question of fact to be resolved by a jury in the light of all the surrounding circumstances."

Employment At Will

An experienced design engineer was employed by a manufacturer for one year with the stipulation that he assign to the employer all cash register mechanisms made by him during that year. It was further agreed that if at the expiration of this contract he left employment while the employer was willing to retain him, he would not enter the service of any manufacturer of similar products for the year immediately following, and that he would assign to this employer any inventions made during that year.

The engineer continued in this employ for 8½ years before accepting employment with a competitor. Within a year after he left, he perfected a cash register to which his former employer asserted a claim under the original employment agreement.

Shortly after the expiration of the original contract, the engineer had asked for, and had been refused, a new agreement. For the remaining period of his employment he had merely been employed at will with no agreement. The New York Court of Appeals, affirming a decision that the employer had no claim to the inventions of the employee, said:[6]

"The inference is reasonable and permissible from all the circumstances that it was the intention of the parties that this employee should give up his definite term of employment for an employment at will, and that the employer voluntarily relinquished its claim on him for inventions made after leaving the employment. The new employment was to supersede the old employment and the old contract was to this extent at least, no longer in effect.

"The new contract as to employment at will was acted upon by both parties. The employee was to that extent excused from performance of the original contract and it would be inequitable to hold him to its terms."

Void Modifications

A further disturbing factor which frequently becomes a source of both controversy and litigation is the extent to which modifications of this character are valid and enforceable.

When an engineer entrusted with the construction of a refrigeration plant discovered that the contract for the machinery had been awarded a manufacturer whose interests were opposed to his own, he took away his plans and specifications, withdrew from the work and refused further services. To induce him to continue, his employer promised him a bonus of 5 per cent of the cost of the machinery. He accepted the offer, but failed to receive the promised bonus upon completion of the job. He sued for recovery. In its decision refusing the engineer recovery, the Missouri court had this to say of the circumstances:[7]

"To permit this engineer to recover under such circumstances would be to offer a premium upon bad faith and invite men to violate their most sacred contracts that they may profit by their own wrong. That a promise to pay a man for doing that which he is already under contract to do is without consideration is conceded.

"The rule has been so long imbedded in the common law and decisions of the highest courts of the various states, that anything but the most cogent reasons ought not to shake it. But it is carrying coals to New Castle to add authorities on a proposition so universally accepted and so inherently just and right in itself.

Old Agreements—New Conditions

The validity of modifications or changes made by the execution of entirely new agreements by the parties raises no doubts. Danger lies in efforts to adapt agreements already existing to changed conditions. A Pennsylvania court saind recently of this phase of contract law:[8]

"The parties to a contract may rescind it by making a new contract inconsistent therewith. The agreement to rescind or modify need not be expressed. Mutual assent to abandon a contract, like mutual assent to form one, may be inferred from the circumstances and conduct of the parties.

"A contract containing a term inconsistent with a term of an earlier contract between the same parties is interpreted as including an agreement to rescind the inconsistent term in the earlier contract. The parties to a written contract may always show that it was subsequently abandoned in whole or in part, modified, changed, or a new one substituted, and this may be established by an express parol agreement or actions necessarily involving alterations."

Mutual Consent

The agreement to modify need not be expressed in words; it may be inferred from acts and declarations of the parties inconsistent with the original contract. Where a new contract is sought, attempts to rehabilitate a former agreement so frequently breed disaster that unless such a method is imperative, a new and comprehensive agreement should always be adopted.

The Maryland Court of Appeals had occasion recently to refer to the futility of efforts at restricting subsequent agreements. Further, it indirectly recognized the benefits of employment agreements made clear and comprehensive to withstand the strains imposed by disagreements and misunderstandings.[9]

"The rule has been accepted by the courts, both state and federal, that even though a written contract stipulates that it may not be varied except by an agreement in writing, nevertheless the parties by a subsequent oral agreement may modify it by mutual consent.

"It has been said that there can be no more force in an agreement in writing not to agree by parol, than in a parol agreement not to agree in writing, and that every such agreement is ended by a new one which contradicts it. Those who make a contract may unmake it. The clause which forbids a change may be changed like any other. Whenever two men contract, no limitation self-imposed, can destroy their power to contract again."

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The Problem:

- **Complex Shapes**
- **Low Quantities**
- **Inexpensive Tooling**

The Answer:

HYDROFORMING

By J. R. Zimmerman
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Formed parts of complex design can be produced in trial quantities, as well as production runs, and with simple inexpensive tooling, by Hydroforming. Popular in the aircraft industry, the process is frequently selected for the freedom it permits in design and because very small production quantities can be made economically.

SUBSTITUTION of simple punches for conventional draw dies enables the Hydroform process to produce complex shapes from sheet metal with a minimum of tooling, lead time, or expense. In addition, due to the unusual way the metal flows about the punch during forming, many parts can be completed in one Hydroforming operation that would require a number of operations with conventional press tooling. A different approach to hydraulic press-forming, the process replaces the conventional female die with a flexible diaphragm that seals off a pressure chamber filled with hydraulic fluid. Entry of the punch into the diaphragm forms the work to the shape of the punch.

Design ideas can be converted into finished prototypes with a minimum of lead time and at low cost. The relatively simple tooling required can frequently be produced from simple drawings or directly from the part drawing, without die designing. The punch, once made up, can be used for

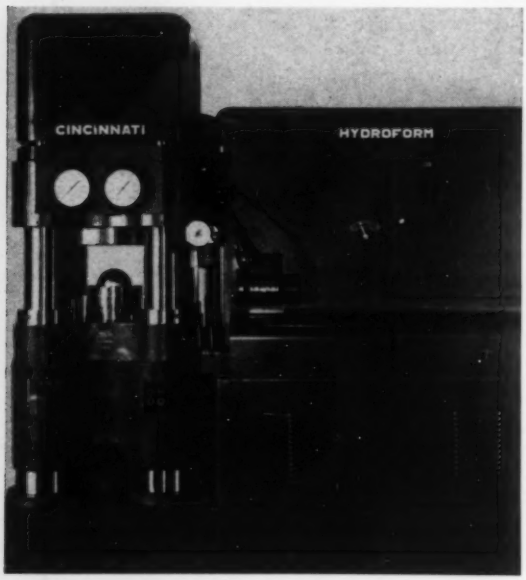
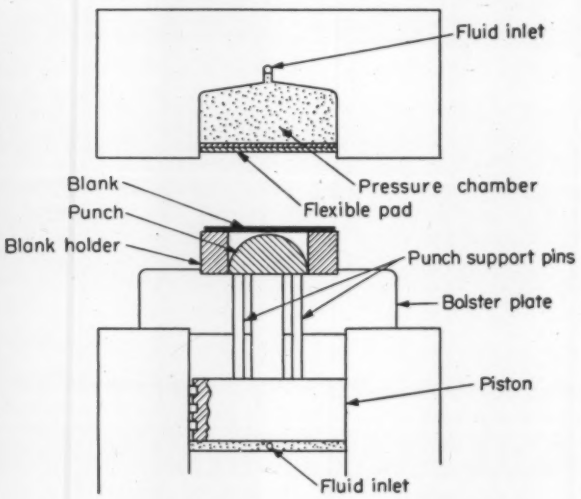
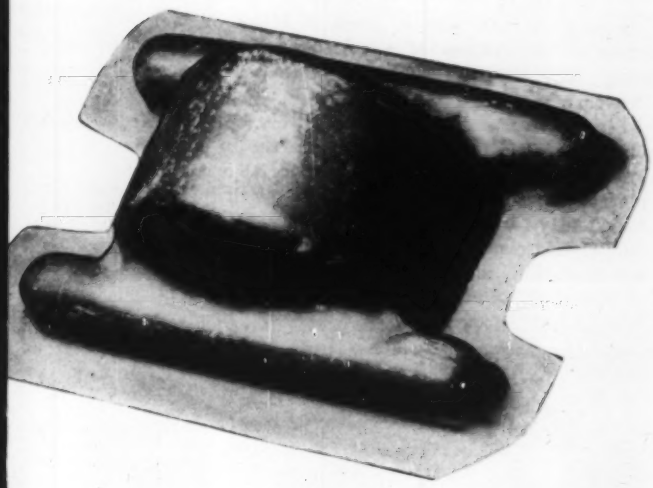


Fig. 1—The Hydroform machine, showing arrangement of pressure chamber, punch and work blank.





producing parts in a wide variety of materials and thicknesses. Since experimental and short-run punches are not hardened, modifications can be readily made to the punch and thus incorporated into the part.

The Hydroform machine, Fig. 1, is basically a hydraulic press with a large cylinder and piston in the base for moving the punch. The top ram has a dome or pressure chamber, sealed from the work area by a rubber diaphragm and layers of flexible material. The hydraulic system provides up to 10,000 psi in the dome, Fig. 2. Movement of the piston into the pressure chamber can increase the pressure to as high as 15,000 psi.

Tooling requirements: Tooling usually consists of a punch, shaped to the form of the desired part, Fig. 3, and a draw ring or blank holder to fit the outline of the punch. Die cost is usually less than 50 per cent of conventional press-tooling. Ordinary oil-hardened steel, cast iron, or tool steel can be used to make the punches; Kirksite, plastics, brass, aluminum, or even hardwood may be used, depending on material formed, shape of the part and quantity required. There is no abrasive action on the punch because the part being formed is literally wrapped down over it. Draw rings are usually made of steel or cast iron and hardened if necessary. Clearance between punch and draw ring can be half the material thickness being formed. The die is self-centering and self-aligning and can be set up in a very short time as compared to the time needed for conventional dies.

Forming the part: The flexible die member (rubber diaphragm) has a cushioning effect and prevents rapid application of strain at any point of the metal. The diaphragm exerts a lateral pressure, locking the metal to the punch radius and distributing the remaining metal uniformly over the entire surface of the punch. Locking the metal against the punch is an advantage, because elongations are localized and can be greater, with-

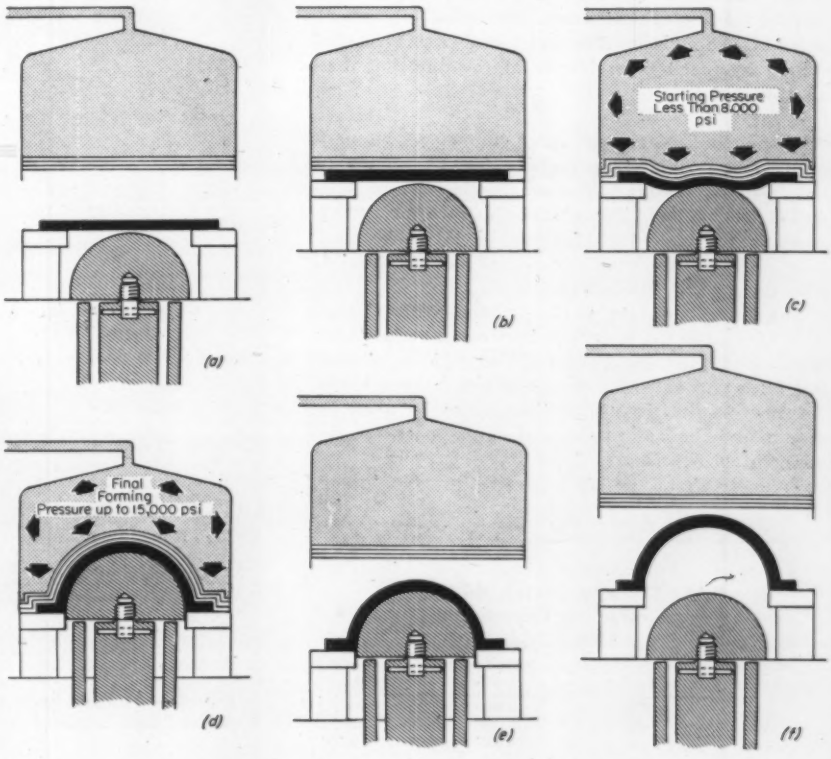


Fig. 2 — Hydroforming cycle begins with dome raised and blank in place, *a*. Dome is lowered, clamping blank to holder, *b*, and starting pressure is applied to force blank against punch, *c*. Punch moves upward, *d*, increasing pressure and forming part. After forming, pressure is released, dome rises, *e*, and work is stripped from punch, *f*.

out undue thickness reduction, than where elongation strain is spread along entire side of drawn part.

Controlled, uniform pressure holding the metal against the punch prevents successive strain concentrations at the punch radius regardless of the depth of draw, permitting the part to be drawn deeply with nearly uniform thickness and eliminating most wrinkles and failures. Naturally, processes cannot change the forming limits of a particular metal. However, the peculiar characteristics of flexible-die drawing do increase the material formability, allowing more severe deformation in one drawing step and reducing the number of operations required to reach the deformation limits of the material, Fig. 4.

Materials and gages: Practically all sheet metals —steel, aluminum, magnesium, copper, brass, silver, etc., can be Hydroformed. Stainless steels, titanium, Nimonic 75, L-605, Inconel, Hastelloy, and stainless-clad copper have been successfully formed. Material used presents the limiting factor for the blank thickness, ranging from foils to 0.375-in. mild steel or 0.625-in. aluminum. Mill variation in the gage of the material can be completely ignored.

Since there is no matching punch and die, different materials and gages can be formed without changing the die by a simple adjustment of the drawing pressure. Table 1 shows the effect of the blank thickness on the maximum height of a formed cup with the same reduction. Sandwich parts of two or more different metals can be drawn simply by placing the blanks of the different metals together.

Shapes and tolerances: Most shapes can be made in one operation. Side embossing and offsets do not require second-operation tooling or a side-action mechanism. The ability to overcome springback is an important feature of Hydroforming; very little or no hand operations are required to give the part its final shape.

Minimum radii on parts formed with flexible dies vary directly in proportion to the metal thickness. Generally, internal radii should be at least 0.095-in. and external radii not less than 0.125-in. Edging or sharpening of the radius between the flange and the wall of the part can be accomplished automatically as part of the forming cycle.

Diameters can be held to within 0.003-in. and part heights to 0.005-in. Flexible female-die drawing methods can also be used to blank or pierce holes in the bottom of a cup by using a piloted plug. The material can also be trimmed during the forming process, Fig. 5.

Since the material is held securely against the punch, surface finishes are not marred or injured. Parts can be formed when the material is painted, plated, highly polished or coated with plastics. Frequently for economy, it is advantageous to combine Hydroforming with other types of metal-forming operations such as conventional press-drawing or spinning to produce the final desired part.

Table 1—Influence of Thickness Variation on Cup Height

Blank Diameter (in.)	Cup Diameter (in.)	Material Thickness (in.)	Cup Height (in.)
12	4 ¼	0.064	5 ⅛
12	4 ¼	0.050	4 ⅞
12	4 ¼	0.037	4 ⅝
12	4 ¼	0.032	4 ½

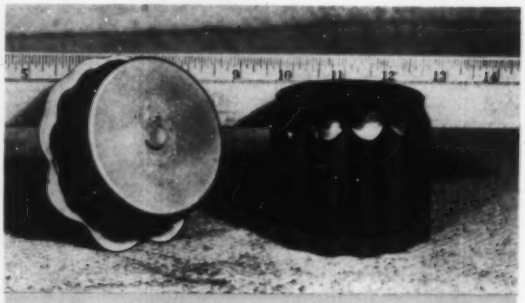


Fig. 3—Complex parts can be formed with simple tooling by Hydroforming.

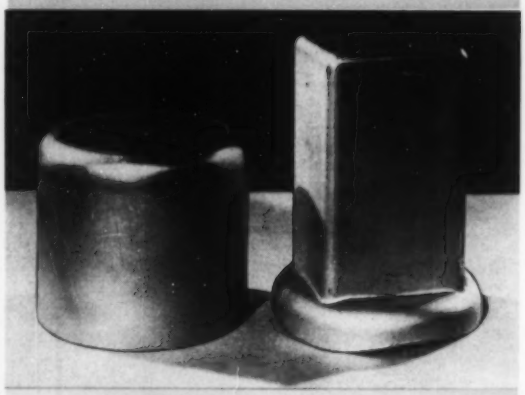


Fig. 4—Deep-drawn aluminum part is Hydroformed in two operations.

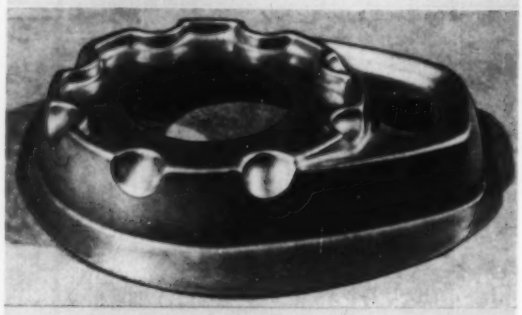
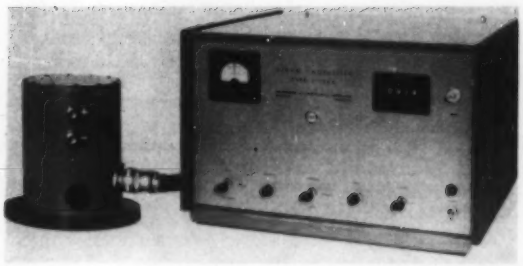


Fig. 5—Intricate brass part is drawn, formed, pierced and trimmed by Hydroforming.

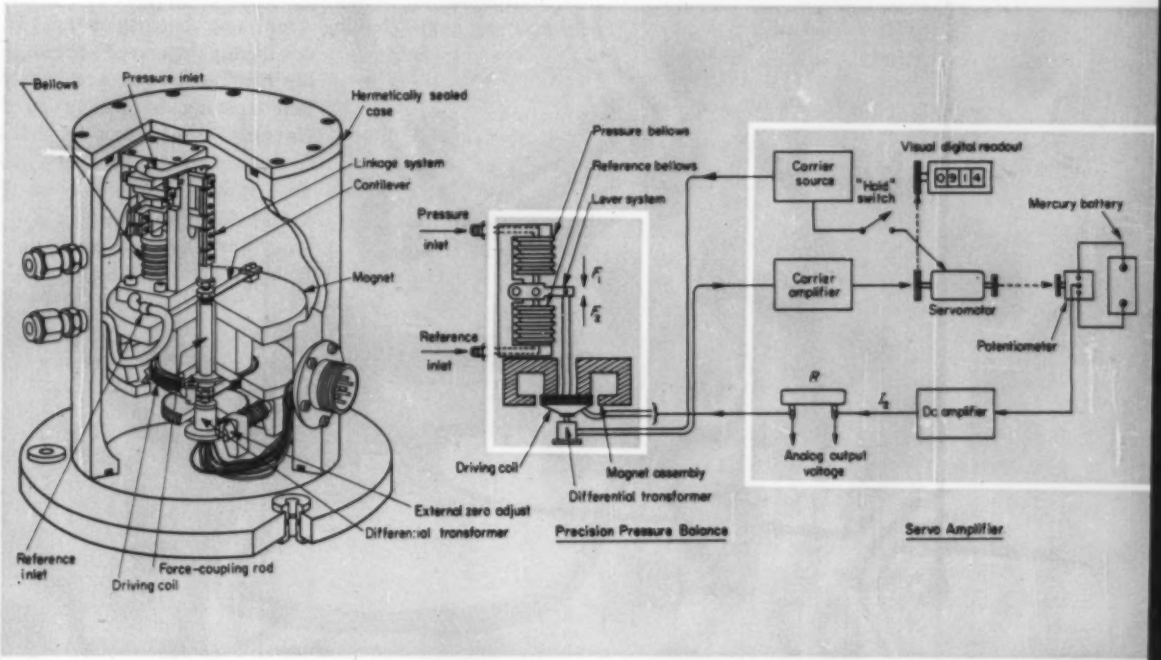
Magnetic Field Balances Forces to Sense Fluid Pressure



Precision pressure-measuring instrument developed by Consolidated Electrodynamics has a fast response time and provides a digital and analog output. The Electromanometer is a self-balancing magnetic force-balance type of commercial unit that provides accuracy equivalent to a laboratory manometer. The instrument consists of two basic units—a pressure balance and a servo amplifier. Pressure ranges of ±1.5 to ±500 psi can be accommodated with this device.

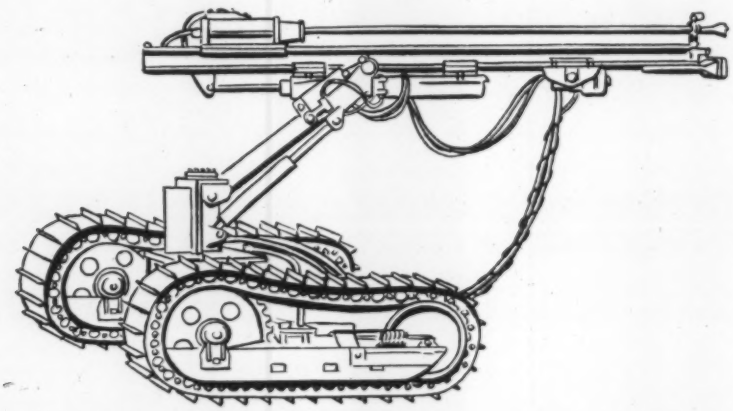
Instrument operation is based on the principle that the force exerted on a conductor in a magnetic field depends on flux density and conductor current. When pressure is applied to the bellows inside the pressure balance, a mechanical force F_1 is developed, causing movement of the linkage system. This movement is, in turn, sensed by a differential transformer. Voltage output from the transformer is amplified and fed to a servomotor which drives a potentiometer and a visual counter.

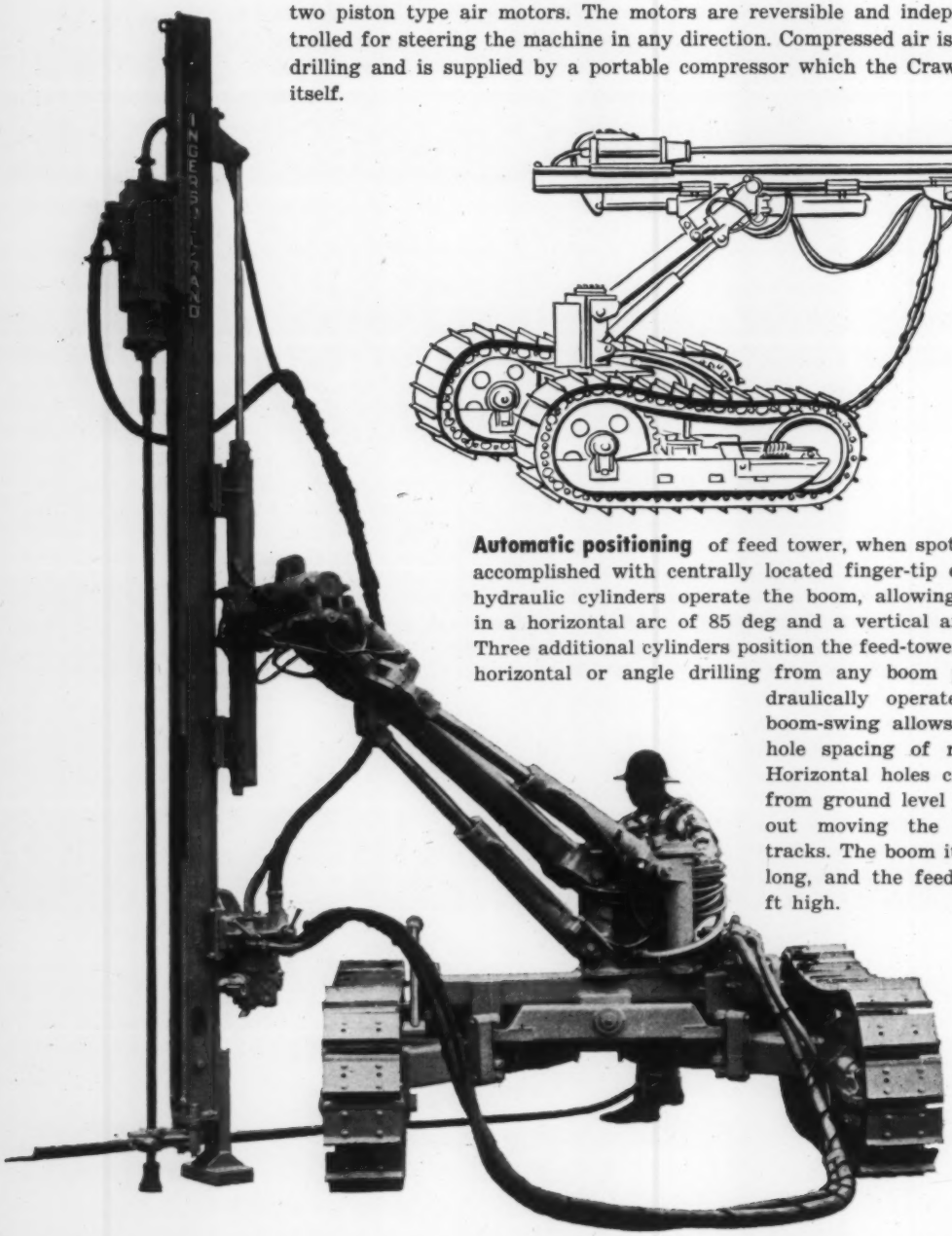
The potentiometer provides a signal for the dc amplifier which produces current in the driving coil. The electrodynamic force F_2 from this coil opposes force F_1, causing a movement of the linkage back to zero position. At null balance, the two forces are in equilibrium. An analog output voltage is developed by current I_2 across resistor R which is proportional to the output force F_2.



Compressed Air Propels Crawler and Drives Drill

Crawler tracks on a new blast-hole drill made by Ingersoll-Rand are driven by two piston type air motors. The motors are reversible and independently controlled for steering the machine in any direction. Compressed air is also used for drilling and is supplied by a portable compressor which the Crawl-IR can pull itself.





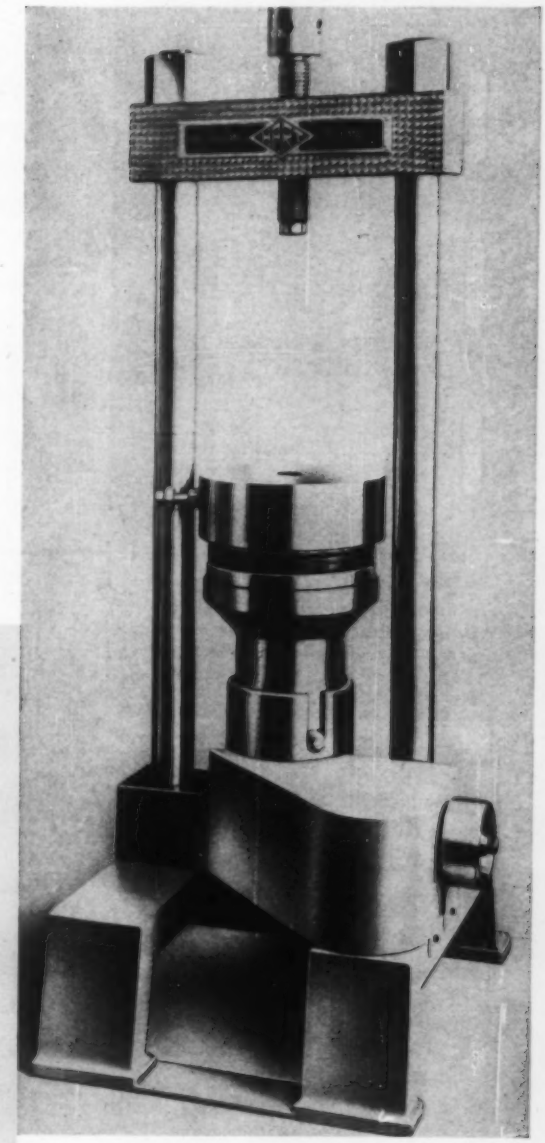
Automatic positioning of feed tower, when spotting holes, is accomplished with centrally located finger-tip controls. Two hydraulic cylinders operate the boom, allowing it to swing in a horizontal arc of 85 deg and a vertical arc of 82 deg. Three additional cylinders position the feed-tower for vertical, horizontal or angle drilling from any boom position. Hydraulically operated horizontal boom-swing allows a maximum hole spacing of nearly 10 ft. Horizontal holes can be drilled from ground level to 7 ft without moving the unit on its tracks. The boom itself is 5½ ft long, and the feed tower is 15 ft high.

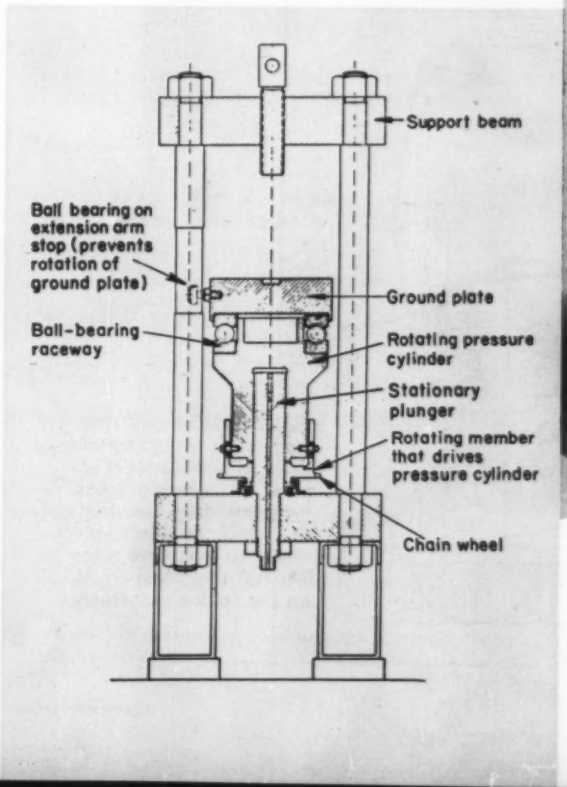
Rotating Linear-Acting Cylinder Reduces Friction

A new Hart hydraulic press available from the Instrument Div., Philips Electronics Inc., operates with extremely low friction characteristics. It is designed for calibrating dynamometers and making similar compression tests where forces up to approximately 66,000 lb are encountered. When properly calibrated, the press can reproduce measurements with an accuracy of better than 1 in 10,000.

In construction a stationary plunger fits a pressure cylinder with close tolerances. The cylinder is raised with high-pressure oil (up to 10,000 psi) which is forced through a bore in the plunger.

To minimize friction, the pressure cylinder is rotated above a critical velocity when measurements are being taken. In this design the critical speed is around 30 rpm, and at this speed the piston literally "swims" in the cylinder. The lowest friction condition is determined by an electrical test; when resistance is highest, the metal surfaces are separated by a layer of oil.





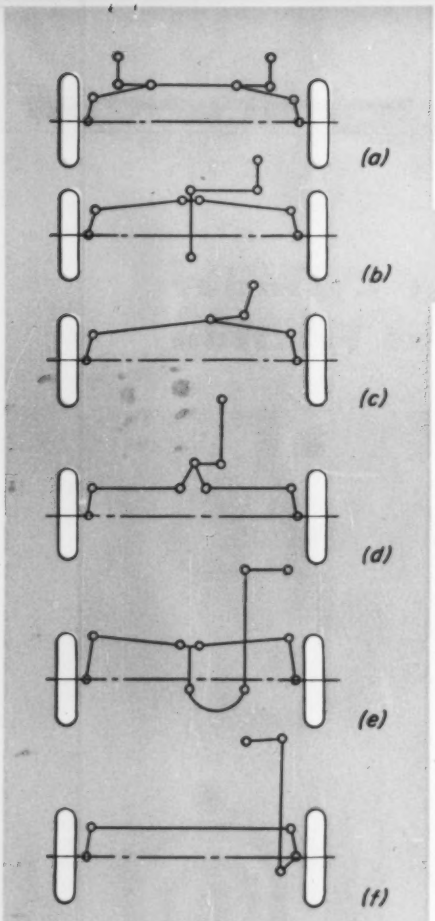


Fig. 19—Typical steering-linkage assemblies. Center-point linkage, *d*, and spindle-lever linkage, *f*, are most common forms in use.

Mechanics of Vehicles-3

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Development Engineer
Towmotor Corp.
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VEHICLE steering geometry is characterized by a wide variety of linkage forms, Fig. 19. Two problems are basic in the design of such assemblies: (1) steering or "cramp" angles must be made sufficiently high for vehicle maneuverability without exceeding practical limitations on linkage size, and (2) camber angles must remain substantially constant as the wheels pass over a bump. Most common of the systems shown are the *center-point linkage*, Fig. 19*d*, and the *spindle-lever linkage*, Fig. 19*f*.

*Now Research and Development Engineer, Phillips Petroleum Co., Bartlesville, Okla.

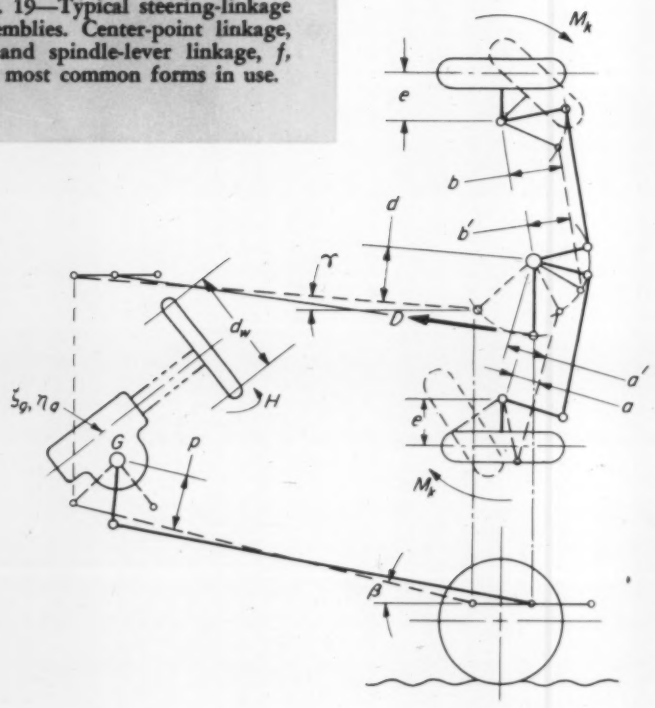


Fig. 20—Rear-axle steering with center-point linkage. Handforce *H* applied to steering wheel produces drag-link force *D*, which is force necessary to overcome steering resisting moment M_k on the stationary vehicle.

Steering Forces and Stability

- **steering geometry**
- **drag-link forces**
- **power steering**
- **ground forces and stability**

Linkage Forces: Analysis of a typical center-point linkage, Fig. 20, shows drag-link force D to be

$$D = \frac{M_k}{d \cos \beta \cos \gamma} \left(\frac{a'}{a} + \frac{b'}{b} \right) \qquad (18)$$

where drag-link angles β and γ are usually small enough to be neglected (less than 15 deg).

For center-point linkage, the steering linkage ratio ζ_s can, for simplification be expressed as

$$\zeta_s = \frac{a'}{a} + \frac{b'}{b} \qquad (19)$$

Substituting this relationship in Equation 18, and assuming $\cos \beta = \cos \gamma \approx 1.0$,

$$D = \frac{M_k \zeta_s}{d} \qquad (20)$$

which is a simplified expression for the drag-link force.

Summing moments at the gearbox output shaft G and using the results of Equation 20,

$$M_g = Dp = \frac{M_k p \zeta_s}{d} = \frac{H d_w \zeta_g \eta_g}{2} \qquad (21)$$

Similar analysis for the spindle-lever linkage, Fig. 21, shows the drag-link force D to be

$$D = \frac{M_k}{d \cos \beta \cos \gamma} \left(1 + \frac{b}{a} \right) \qquad (22)$$

Steering-gear linkage ratio ζ_s is

$$\zeta_s = 1 + \frac{b}{a} \qquad (23)$$

which, when substituted into Equation 22, gives

$$D = \frac{M_k \zeta_s}{d} \qquad (24)$$

Summing moments as before at the gearbox output shaft,

$$M_g = Dp = \frac{M_k p \zeta_s}{d} = \frac{H d_w \zeta_g \eta_g}{2} \qquad (25)$$

which is identical to the relationship derived for the center-point linkage.

Nomenclature

A = Area, sq in.
a, a' = Steering-linkage lever arms, in.
B, B_i, B_o = Decelerating forces (subscripts i and o refer to inside and outside wheels, respectively), lb
b_t = Nominal tire width, in.
b, b' = Steering-linkage lever arms, in.
C = Centrifugal force as side thrust, lb
c = Action arm of the cornering force, in.
D = Drag link force, lb
d = Steering lever arm, in.
d_p = Hydraulic-cylinder diameter, in.
d_r = Piston-rod diameter, in.
e = King-pin offset (projected distance on the ground), in.
h = Effective moment arm of steered wheel, in.
F = Power-steering cylinder force, lb
H = Manual steering effort (handforce) on the wheel, lb
I_o = Polar moment of inertia of the tire footprint, in.^{4}
k = Polar radius of gyration of the tire footprint area, in.
M_g = Torque on the steering-gear output shaft, lb-in.
M_{ik} = Moment around the king pin due to king pin inclination, lb-in.
M_k = Moment around the king pin required to turn one stationary wheel, lb-in.
M_s = Static steering moment around footprint center, lb-in.
P_p = Pump power, hp
Q = Flow rate, gpm
S = Cornering force or side thrust, lb
S_i, S_o = Side forces (subscripts i and o refer to inside and outside wheels, respectively), lb
S_v = Force required to actuate valve, lb
t = Steering time, sec
W = Weight or load, lb
α = Steering angle, deg
θ = King pin inclination, deg
ζ_s = Linkage reduction ratio
ζ_g = Steering-gear reduction ratio
ψ = Slip angle, deg
μ_s = Coefficient of sliding friction
μ = Effective coefficient of friction of a steered tire
η_g = Steering gear efficiency

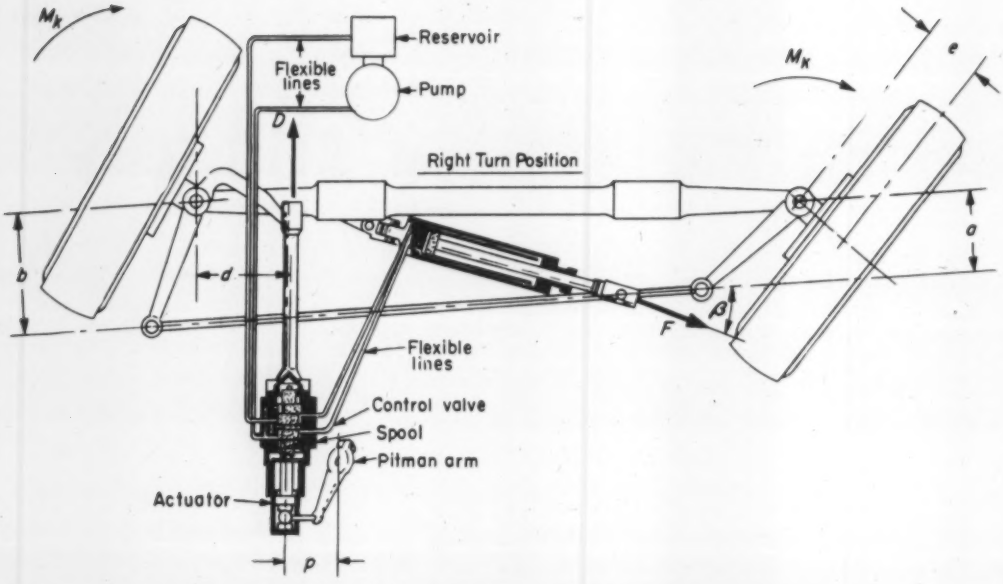


Fig. 21—Spindle-lever linkage with power-steering accessories (Bendix). If handforce applied to the steering wheel exceeds the force required to operate the control valve, the manual-steering force supports efforts of the power cylinder.

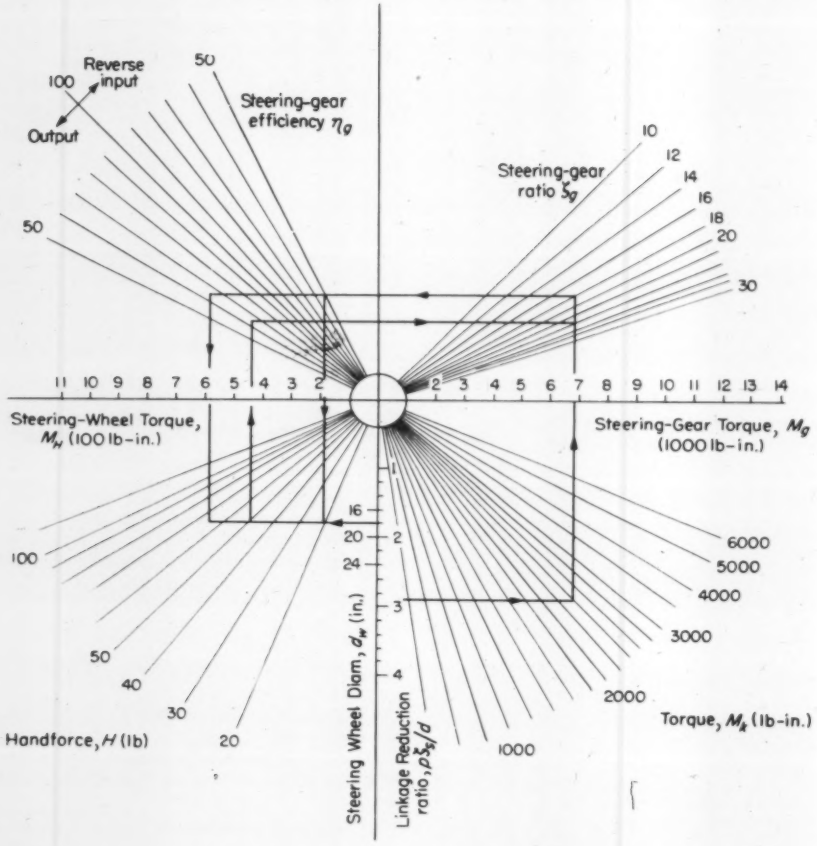


Fig. 22—Manual-steering calculation chart, representing Equation 21.

Relationship among the principal steering-linkage design variables—that is, a plot of Equation 21—is given in Fig. 22. Use of the chart to determine steering-linkage parameters is illustrated by Example 1.

In an evaluation of steering linkages, a plot of steering-gear torque M_g as a function of steering angle is useful, Fig. 23. A good steering layout gives no more than 15 per cent variation in M_g between extreme wheel positions. Should torque variations fall outside this limit, steering-linkage elements can be altered in length and angular position until the torque-angle curve is as desired.

Handforce required to steer a stationary vehicle is usually restricted to certain arbitrary design limits. Generally accepted values—assuming vehicle operation on smooth, dry concrete—are given in Table 2.

Power Steering: If the manual effort required for steering approaches or exceeds practical limits, power steering can be used. Essential elements of

Example 1—Steering Force Calculation

Problem: Calculate all essential elements of a steering system for a vehicle with 3400 lb weight on the steering axle. King-pin offset e is 2 in.; steering-wheel diameter d_w is 18 in.; the proposed steering gear has ratio 18:1 and 65 per cent efficiency. Reduction of the linkage reaches maximum for an extreme steering angle. At this point, the following data have been determined (Fig. 20): $a = 7.5$ in.; $b = 10$ in.; $d = 9$ in.; $p = 11$ in. Tire size is 7.60 x 15.

Manual-Steering Solution: Torque required to turn a stationary wheel around the king pin is calculated from Equation 16.2 (Part 2). Data necessary for use of the equation are determined from the conditions of the problem.

Square of radius of gyration k of the footprint area is given by Equation 17 (Part 2) as

$$k^2 = \frac{b_t^2}{8} = \frac{7.60^2}{8} = 7.2 \text{ sq in.}$$

The effective coefficient of friction μ, taken from Fig. 17 (Part 2) for a value of the ratio $e/B = 2/7.6 = 0.26$, has the value $\mu = 0.42$.

The effective torque arm is given by Equation 16.1 as

$$h = \sqrt{k^2 + e^2} = \sqrt{7.2 + 4} = 3.3 \text{ in.}$$

With one wheel carrying half the axle load, the moment around the king pin as given by Equation 16.2 is

$$M_k = \mu W h = (0.42)(1700)(3.3) = 2350 \text{ lb-in.}$$

From Equation 21 or from the chart in Fig. 22, steering-gear torque and required handforce on the steering wheel can be found. Steeraxle linkage reduction ratio is found from Equation 23 as

$$\zeta_s = 1 + \frac{b}{a} = 1 + \frac{10}{7.5} = 2.33$$

The total reduction factor as used in the chart will be:

$$\frac{p\,\zeta_s}{d} = \frac{(11)(2.33)}{9} = 2.9$$

For the given values, Fig. 22 gives the steering gear torque $M_g = 6800$ lb-in. and the handforce $H = 65$ lb.

From Fig. 22, it can be seen that the same gear torque induced as shock from the steered wheels could be resisted by a handforce on the steering wheel of only 20 lb. In such a case, the reverse input efficiency of the gear (assumed to be 50 per cent) will consume part of the disturbing torque.

Should a handforce of 50 lb be desired as acceptable maximum, a gear with the ratio of 24:1 should be used.

To check for king pin inclination effect, assume $\theta = 6$ deg and the steerangle $\alpha = 40$ deg. From Equation 14 (Part 2),

$$M_{ik} = eW \sin\theta \left(\frac{1 - \cos\alpha}{\sin\alpha} \right) = (2)(1700)(0.1) \left(\frac{1 - 0.76}{0.64} \right) = 12.8 \text{ lb-in.}$$

which is a negligible torque.

Power Steering Solution: Steering handforce as calculated in the first part of this example may be excessive. Power steering can then be considered.

From Fig. 21, the moment equilibrium equation around the left king pin is

$$M_k + \frac{M_k b}{a} = d \left(\frac{H d_w}{2p} \zeta_g \eta_g - S_v \right) + b \eta_c F \cos\beta$$

This equation includes the steering supporting effect of handforce H, the reaction force of the actuating valve (in S) and the efficiency η_c of the hydraulic cylinder. The effect of these elements is partly compensating and can usually be neglected.

The simplified equation for the required cylinder force is then

$$F = \frac{M_k \zeta_s}{b \cos\beta} = \frac{(2350)(2.33)}{(0.94)(10)} = 600 \text{ lb}$$

An available cylinder has a bore $d_p = 1.75$ in., a piston-rod diameter $d_r = 0.75$ in. and a net area A on the piston-rod side of 2.0 sq in.

From the chart in Fig. 26, it is seen that a pump will be required that can deliver hydraulic fluid at 400 psi at an approximate rate of 2.25 gpm. This performance should be achieved at a pump speed corresponding to engine idling speed. The expected steering time will be between 2.5 and 5 sec, which is satisfactory.

Table 2—Steering-Handforce Limits

Vehicle	Handforce, H (lb)
Passenger car	45
Trucks and industrial vehicles	80
Very heavy vehicles	100

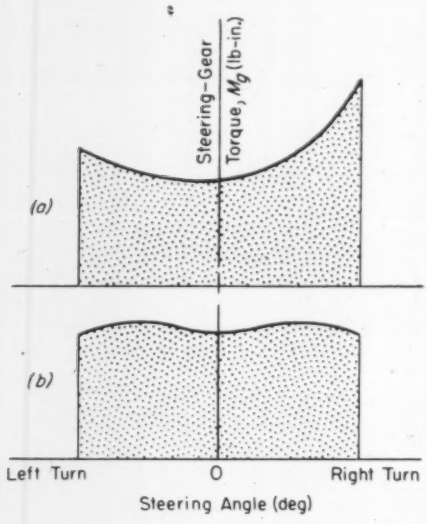


Fig. 23—Torque on gearbox output shaft as function of steering angle. An example of poor steering-gear design is shown at *a;* torque peaks on one side of straight-ahead position. Desirable torque distribution is shown at *b*. Shaded area under each curve represents work performed by steering gear and is unaffected by changes in linkage reduction, gear ratio or angular linkage travel.

the usual power-steering system, Figs. 21 and 24, are described in the following sections.

DOUBLE-ACTING HYDRAULIC CYLINDER: Integral with the steering gear, or mounted as a separate booster, Fig. 25, the hydraulic cylinder can act on any steering-linkage element. Effective work performed by the cylinder is in each case the product of force and displacement. Steering work is substantially constant for various combinations of cylinder diameter, stroke and fluid pressure. Quality of power steering will, to a large extent, depend on the proper balancing of these elements. Force required from the cylinder can be calculated from equilibrium of moments around an appropriate point (see Example 1).

ACTUATOR VALVE: Flow of hydraulic fluid under pressure is directed to the proper cylinder port by an actuator valve. The valve can be integral with the steering gear, integral with the cylinder, or separately mounted in the drag-link line. Wherever the valve is mounted, its action is the same: torque applied by hand to the steering wheel opens one valve port, supplying oil under pressure to one side of the cylinder. The other port simultaneously directs the return flow from the cylinder back to the reservoir. If the handforce acting on the steering wheel exceeds the force required to actuate the valve, it supports the effort of the hydraulic cylinder.

HYDRAULIC PUMP: Power source for a steering system is a hydraulic gear pump which supplies a definite volume of hydraulic fluid at the required pressure p_f. Power to drive the pump can be calculated from the general pump equation

$$P_p = \frac{Qp_f(144)}{\eta(550)(449)} \approx \frac{Qp_f}{(1770)\eta} \qquad (26)$$

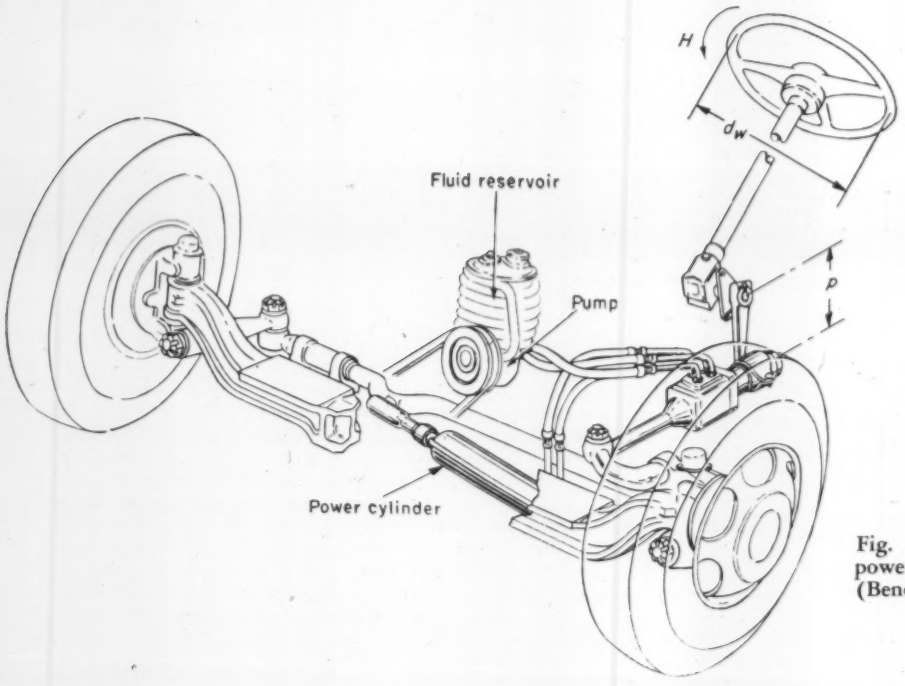


Fig. 24 — Typical power-steering system (Bendix).

where P_p = power required (hp), Q = volume output (gpm), p_f = pressure (psi) and η = total efficiency of the pump (usually 70 to 80 per cent). Characteristic curves supplied by pump manufacturers showing the relation between Q and p for different pump speeds are, in practical applications, often distorted by use of flow-control and relief valves. It is therefore advisable to find actual pump output by experiment.

Volume output of the pump will determine the time necessary to fill the hydraulic cylinder displacement. Speed of the cylinder piston should be high enough so that it cannot be overtaken by a handforce turning the steering wheel with an average speed of about 1.5 rev per sec. A good power steering design will achieve full turn of the wheels in 3½ to 4½ revolutions of the steering wheel, giving a total time available to fill the cylinder of from 2.3 to 3 sec.

The following equations correlate the variables of a power steering system:

$$Q = \frac{60(As)}{231(t)} \qquad (27)$$

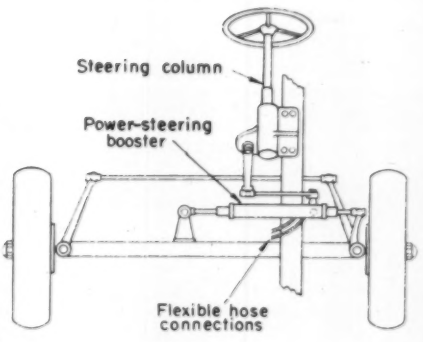
$$F = Ap = \frac{p\pi(d_p^2 - d_r^2)}{4} \qquad (28)$$

where Q = rate of flow (gpm), A = effective cylinder area (sq in.), d_p and d_r are cylinder and piston-rod diameters (in.), s = piston stroke (in.), F = cylinder force (lb), and t = steering time for full turn (sec).

Relations between these interdependent variables are represented in a working chart, Fig. 26. Co-ordination among the design elements can be quickly established by use of this chart.

Steering Stability

Forces acting on a tire in the ground contact area will exert torques around the king pin and consequently affect steering stability of the vehicle. The effect can be steer-angle increasing, which is an undesirable condition of inherent instability, or steer-angle decreasing, which is the desired



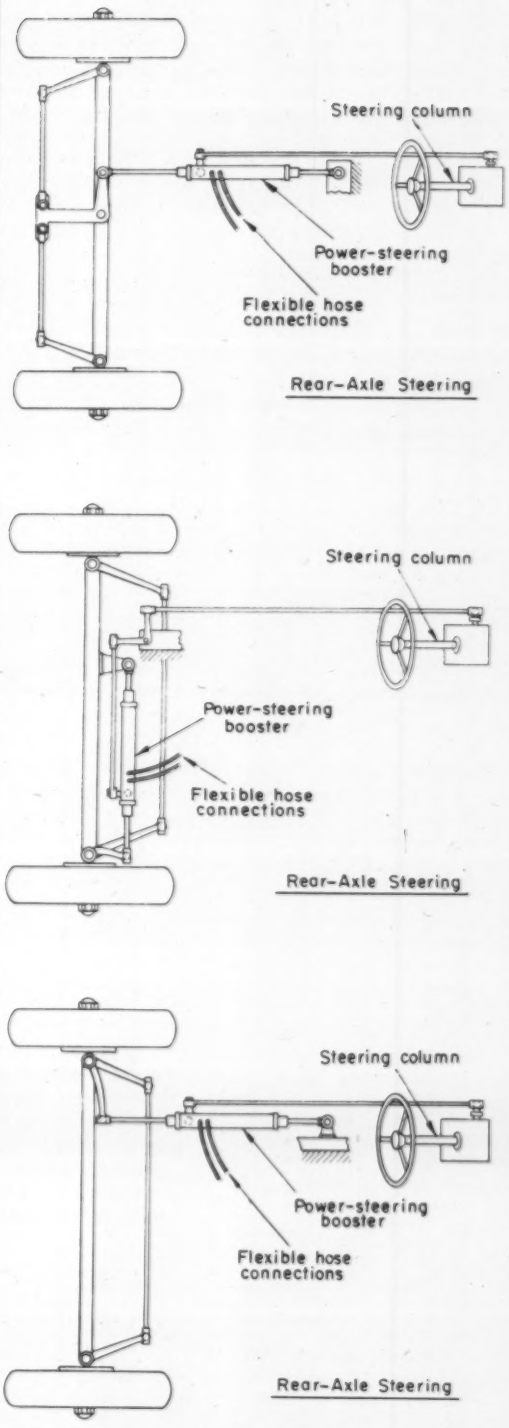


Fig. 25—Typical booster-type power-steering installations (Vickers). Generally, the advantage of the booster-type system is that the force reaction on the power cylinder is supported by the vehicle frame structure.

self-aligning tendency.

Forces and Stability: Forces that must be investigated are: (1) tractive forces, applicable when the steered wheels are also the drive wheels; (2) decelerating forces, including the always present rolling resistance and the braking force if applicable; (3) cornering forces (reaction of the tire to side forces) acting perpendicular to the rolling direction.

Influence of these forces on steering is shown in Fig. 27. The three basic situations are discussed in the following sections.

STRAIGHT-AHEAD DRIVING: Tractive or decelerating forces, in this case, produce opposite but equal moments on left and right wheels, Fig. 27*a*.

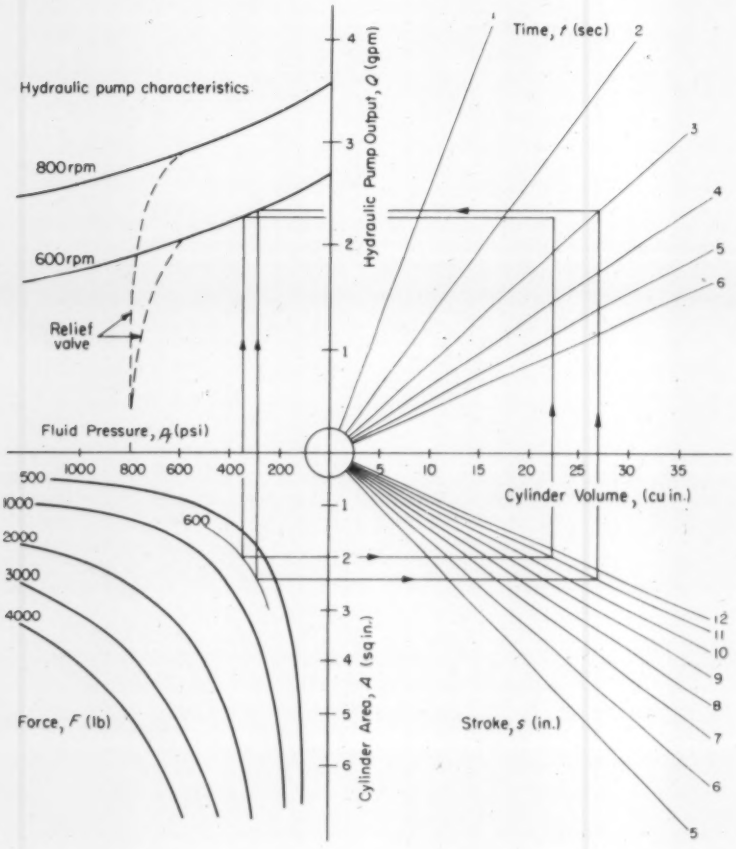


Fig. 26—Power-steering calculation chart, representing Equations 27 and 28. Pump characteristics are approximate and can be replaced by exact values if desired.

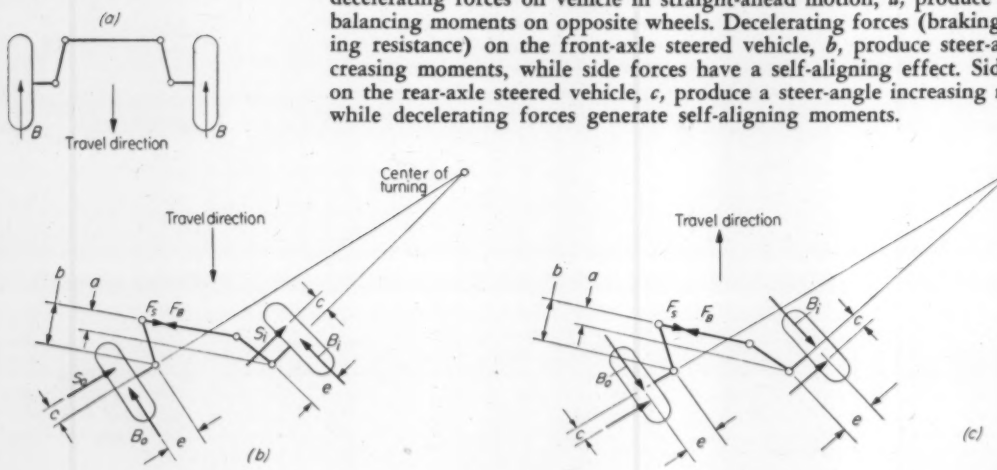


Fig. 27—Effect of ground-plane forces on steering stability. Tractive or decelerating forces on vehicle in straight-ahead motion, *a*, produce counterbalancing moments on opposite wheels. Decelerating forces (braking or rolling resistance) on the front-axle steered vehicle, *b*, produce steer-angle increasing moments, while side forces have a self-aligning effect. Side forces on the rear-axle steered vehicle, *c*, produce a steer-angle increasing moment, while decelerating forces generate self-aligning moments.

Torques therefore balance and have no effect on steering.

STEERED FRONT AXLE: A decelerating force B, Fig. 27*b*, creates the steer-angle increasing tie-rod force $B_i(e/a)$ on the wheel on the inside of the curve and a self-aligning tie-rod force $B_o(e/b)$ on the wheel on the outside of the curve. As lever arm a of the inside wheel is, because of tie-rod geometry, always smaller than arm b, the total effect of a decelerating force is steer-angle increasing. The tie-rod force is then

$$F_b = \frac{B_i e}{a} - \frac{B_o e}{b} \qquad (29.1)$$

Tractive forces acting in the drive direction will produce a self-aligning torque. On front-wheel drive vehicles, therefore, less caster angle is normally used, since self-aligning effects derived from the tractive force are sufficient.

Cornering forces S of both wheels act in the self-aligning sense, producing in the tie rod the force

$$F_s = \frac{S_i c}{a} + \frac{S_o c}{b} \qquad (29.2)$$

Value of the self-aligning torque depends on the length of moment arm c. Moment Sc is the self-aligning torque commonly called the caster effect. This action of the cornering force is important, since it overbalances the steer-angle increasing effect of rolling resistance.

STEERED REAR AXLE: On rear-axle steered vehicles (or front-axle steered vehicles driven backward) Fig. 27*b*, decelerating forces produce the self-aligning tie-rod force

$$F_b = \frac{B_i e}{a} - \frac{B_o e}{b} \qquad (30)$$

The cornering force, however, creates a steer-angle increasing torque, resulting usually in inherent instability of the rear-axle steered vehicle. Negative caster angle may be applied in such cases, reversing the rotation sense of the cornering force around the king pin.

Slip-Angle Steering: It has been shown in a preceding section that any side force acting on a vehicle requires a counterbalancing cornering force of the same value. To produce the cornering force, the tire will run at a slip angle that is proportional to the force required.

Top view of a vehicle driving in a curve is shown in Fig. 28. The theoretical center of curvature, which for Ackerman steering is on the prolonged rear-axle axis, cannot be maintained if the wheels must run at a slip angle. To create the slip condition, the actual center of curvature is always ahead of the theoretical center.

If cornering powers of front and rear tires are different, or if weight distribution results in unequal side forces on front and rear axles, Fig. 29, equilibrium between side-thrust and cornering forces will be reached at unequal slip angles for front and rear tires. Such an effect can give rise

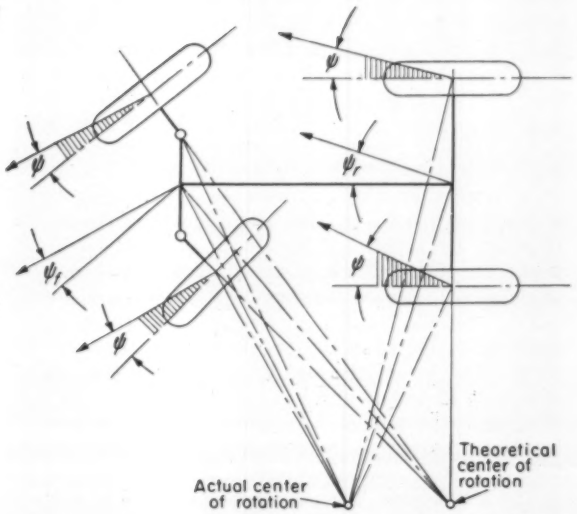


Fig. 28—Actual center of rotation of a vehicle negotiating a curve falls ahead of the theoretical center because of differences in slip angles of front and rear wheels.

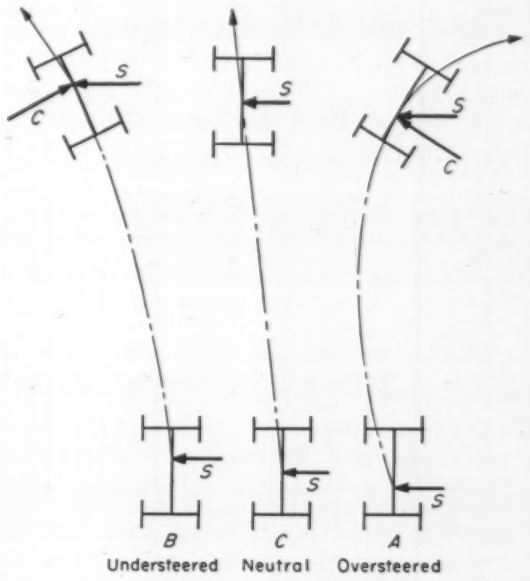


Fig. 29—Effect of slip angles on directional stability. Vehicles *A*, *B* and *C* are subjected to identical side forces *S* at different points along the vehicle centerlines. Rear-axle heavy vehicle *A* will "oversteer" and turn toward side force *S* because the slip angle on the rear axle is greater than the slip angle on the front axle. Centrifugal force created by the curvilinear motion adds to the force *S*. Front-axle heavy vehicle *B* "understeers," turning away from the disturbing force. Vehicle *C* with neutral steering characteristics follows a straight line.

to the following steering conditions:

OVERSTEERING: If the slip angle on the rear axle is greater than on the front axle, the rear end of the vehicle will drift away in the direction of the exciting force into a course of increasing curvature. Centrifugal forces created will add to the primary disturbing force. Oversteering is therefore a situation of inherent instability.

UNDERSTEERING: If the front-axle slip angle is greater, the course of the vehicle will have a self-straightening tendency, that is, away from the exciting force. The centrifugal force produced by the curved motion will subtract from the initial disturbance. This is a desirable condition of inherent stability.

It should be emphasized that slip-angle steering bears no relation to the actual steering of the vehicle. Conclusions reached would have the same validity for a towed trailer. Disturbing forces may be centrifugally caused, or result from any other side-thrust producing disturbance. With a side-wind force, the complexity of the problem is multiplied, since the aerodynamic properties of the body enter the picture.

The influence of slip-angle steering on the directional behavior of a vehicle is shown in Fig. 29. The same side force S acts at different points on vehicles A, B and C. Vehicle A is rear-axle heavy and therefore oversteered; vehicle B is front-axle heavy and therefore understeered. Path of the oversteered vehicle is toward the center of the disturbance with increasing curvature, while curvature of the path of the understeered vehicle is decreasing. For comparison, the ideal line of a neutral steering path is shown. This represents a vehicle with identical slip angles on both axles. Should the disturbing force disappear, the oversteered vehicle continues in a path of increasing curvature due to continued centrifugal force, while the understeered vehicle straightens out by itself.

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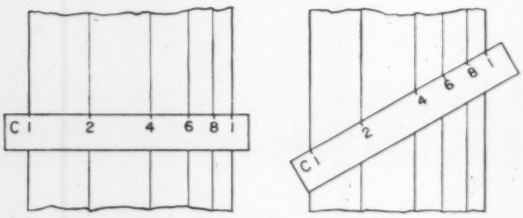
Tips and Techniques

Handy Log Scale

To improvise a logarithmic scale for plotting curves on a log or semilog graph, the slide from a slide rule may be used. It is laid along the axis and the points on the slide are marked on the



paper. If neither the C nor B scale are of convenient length, the slide can be placed at an angle to the axis and the logarithmic co-ordinates marked as required.—JESSE ROTH, *Curtiss-Wright Corp., Calstadt, N. J.*

Drawing Irregular Curves

When drawing curved lines that have portions with very sharp or irregular curvature, a convenient supplement to French curves is a length of wire solder. It can be easily bent to the required shape and straightened out after use. The wire should be solid, not flux-core. To avoid the occasional marks that solder will leave on paper, vinyl tubing (spaghetti) may be slipped over the solder.—JESSE ROTH, *Curtiss-Wright Corp., Carlstadt, N. J.*

Measuring Angles

An angle of less than 15 degrees can be measured with considerable accuracy without the use of a protractor. The hypotenuse is extended to a length of 7 5/32 in. The angle may then be determined by measuring the length of the side opposite the angle. Each $\frac{1}{8}$-in. of length represents one degree. Errors inherent in this method are slight. A side length of 0.125-in., indicates an angle of 1 degree, while the angle is actually 1° 0′ 6″. The error increases as the angle does; an apparent 15-degree angle is actually 15° 11′ 21″. The method is practical for most purposes because extreme accuracy of measurement is necessary before the error becomes apparent. For instance, the method indicates that a one-degree angle will have a side opposite with a length of 0.125-in. The actual length is 0.1249-in., an error of 0.0001-in. For a 15-degree angle, the assumed length is 1 5/8 or 1.875; actual length is 1.8522 in., a difference of 0.0228-in.—WILLIAM LOCKE, *Cincinnati.*

The Personal Side of Engineering

By Edwin C. Nevis
Personnel Research and Development Corp., Cleveland

Is Selling for Me?

SOME time ago, we were asked by a manufacturing company to make a psychological evaluation of one of its sales engineers who was not performing up to expectations. This man graduated with a degree in mechanical engineering. He had several years of experience in design and development work before taking a position as a sales engineer with the company. By virtue of intelligence, experience, training, and determination to get ahead in the business world, he seemed eminently qualified to do a good job in a sales capacity.

Following an intensive evaluation of this man, the reason for his difficulty became apparent. For one thing, his motivation in going into sales work was largely its income potential. He also believed sales to be his best avenue for advancement into an executive capacity. But he was not especially interested in the challenge of interacting with people, particularly in a capacity which called for him to sell himself and his ideas to others.

It also seemed that he was made uneasy by the fact that he could put a great deal of effort into his work and yet find tangible results slow in coming. Apparently he was capable of a fair degree of patience and tolerance when tackling a strictly technical problem because he could see results follow closely upon the heels of his day-to-day activity. In the selling situation, however, he found that he would frequently get little or no response from a potential customer. He would present what was to him a logical, intelligent, and highly factual account of his company's services and their value to the customer. Then, getting no response, he would give up too easily in his efforts to land an order.

These findings were discussed with management and with the individual concerned. It was decided to change this engineer's assignment, bringing him back into development work. His performance since then has been quite satisfactory.

This case has a bearing upon the growing trend today for engineers to consider going into sales as opposed to design, research, or manufacturing. It is true that more and more sales assignments now call for a man with an engineering degree and a good deal of technical experience. But many engineers look longingly at the possible rewards of a sales career without giving adequate attention to the requirements for success in selling—to say nothing of the many disadvantages that such work might entail.

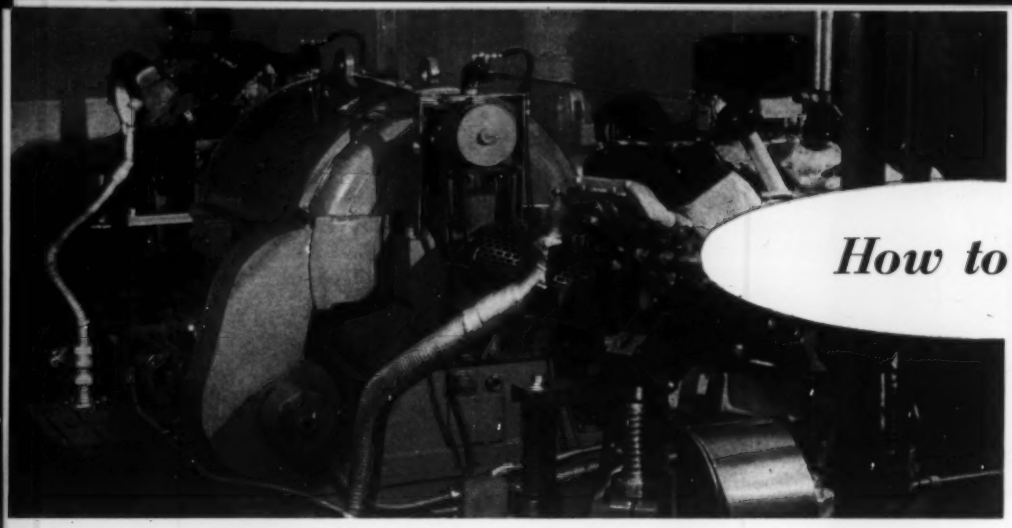
Research and experience in the field of vocational counseling indicate two important conclusions which should be considered by anyone faced with a choice of career efforts.

The first conclusion: there is no single, best road to the top. The engineer, the accountant, the salesman are, by virtue of their training and background in any one of these fields, no more likely to advance into executive capacities than the other. There is little evidence to support the frequent statement that sales managers are more likely to succeed into executive positions than production managers, according to a study by Newcomer of "The Big Business Executive." If anything, engineers going into areas related to production and operations have a better chance of advancing to top positions than salesmen.

The second point of importance: we are most likely to be successful when doing those things about which we feel comfortable and for which we can muster our energy and capacities with little or no tension or anxiety. Most individuals will be more comfortable and productive in one type of endeavor than in another. And even if the times appear to be "good" for salesmen and "poor" for engineers, the individual who has more basic desire, interest and aptitude for one type of work will do best by building his career along that particular line.

Evidence indicates that most successful salesmen and sales engineers have a strong and deeply felt need to win acceptance from other people. This is not simply a liking for people or a desire to have many acquaintances, but rather a need to deal continuously with others in an attempt to win favor and to be liked. This implies, among other things, the willingness and skill to be exceptionally flexible. A salesman must be able to adjust behavior and sales approach to the differences between the individuals with whom he is dealing.

The typical engineering approach is based on logic and consistency in solving problems. Unless an engineer is highly motivated along the flexible, "people-sensitive" lines just outlined, he may experience some difficulty in adjusting to the role of a sales engineer. Engineers interested in a sales career, or who feel that sales is an avenue through which they can best advance, should consider the idea. But before swapping a position as a research engineer for a possible increase in pay as a sales engineer, a man should weigh all of these considerations with the utmost of care.



How to choose

Three basic types of electric dynamometer equipment are available. This article describes factors that influence their selection and application in development and design of rotating machinery.

EXACTING need for accurate measurement of torque and power provides a challenge for which the electric dynamometer is singularly adapted. Rapid advancements in the development of engines, turbines, pumps and compressors can be made only if torque and power capacities of these devices are measured accurately. Performance and change in performance of all elements of power transmission systems must be measured accurately enough to determine whether modifications of design have produced overall gains or losses. For example, since approximately three-fourths of the power developed by the turbine of a modern jet engine is required to drive the compressor for the engine, minor improvements in either the turbine or compressor can result in major increases in performance of the engine. Real advances can be made only if design changes in either the turbine or the compressor can be related to the torque and power characteristics of the components and the complete engine. Development programs in all rotating equipment fields provide many similar examples of the increasing need for sensitive and accurate torque and power-measuring equipment.

In addition to testing and development of power transmission systems, the electric dynamometer is a significant tool in the development of component and associated equipment. The single-cylinder test stand permits basic studies of the effect of combustion-chamber design, combustion efficiency, weight of reciprocating parts, sealing-ring design and many other fundamental combustion problems by utilizing the accuracy and sensitivity of the electric dynamometer. Associated equipment, such as transmissions, axles and fluid couplings, may be separated from the overall problem and studied individually by means of electric dynamometers, which provide accurate measurement of both the input and output power of these devices. Auxiliary devices, such as fans, pumps and compressors, are easily tested on dynamometer equipment.

Special test stands for studying belts, tires and similar associated parts permit the best utilization of power. The electric dynamometer thus furnishes an invaluable tool for study and development of the complete power system, from fuel testing to studying the completely assembled power system with all auxiliaries and components.

Mechanical Features

The electric dynamometer is most commonly used in two basic types of mechanical construction.

Cradled Construction: Where greatest possible accuracy and sensitivity is required, the cradled dynamometer is most frequently used. In this construction, the dynamometer is supported in low-friction trunnions which permit it to rotate freely. A high-accuracy force-measuring device prevents rotation of the dynamometer frame. The reaction on the scale or other load-measuring equipment—located at an accurate distance from the dynamometer center-line—measures the reaction torque of the cradled dynamometer. This torque, combined with the operating speed, indicates the power being absorbed.

Block-Test Construction: Where accuracy and sensitivity are of secondary importance, as is frequently the case in endurance testing and produc-

Electric Dynamometers

for research and development

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tion testing, the block-test dynamometer may be most suitable. In this case, the mechanical output or input to the dynamometer is related to its electrical output or input, while mechanical torque is measured by means of calibrated meters and calibration curves for the dynamometer. Lower initial cost and reduced maintenance make the block-test dynamometer very attractive, especially when the highest degree of sensitivity and accuracy is not required.

Electrical Features

There are three principal types of electrical construction commonly in use today, any of which can be built in the cradled or block-test mechanical type.

Eddy-Current Type: The eddy-current dynamometer, designed for the widest range of speeds and loads, is normally built with a smooth member which rotates relative to a toothed member. Either the rotor or stator of the eddy-current machine can be used as the toothed member. Power absorption is provided and controlled by a dc exciting coil usually placed in the center of the toothed member.

Normally, while not capable of the high accuracy of the dc and induction alternator types, the cradled eddy-current dynamometer is a simple and reasonably accurate method of measuring output power. Having no motoring capacity, it is not satisfactory for measuring input power. In most cases, the eddy-current dynamometer has very high overload capacity for short periods of time. While not costly, maintenance is likely to be more frequent with the eddy-current type dynamometer than with others. Although not satisfactory for measuring power when built in block-test construction, the eddy-current principle can be used to excellent advantage for production testing when an inexpensive source of load absorption is necessary.

DC Type: The direct-current dynamometer is essentially a dc generator and may be built either in cradled or block-test construction. In its simplest form, the dc dynamometer requires an exciter and source of dc power for motoring operation or an exciter and loading grids for an absorption function. Much more flexible, the direct-current dynamometer can be operated in a Ward Leonard system using a motor-generator set and exciter. In this form, the direct-current dynamometer is very simple to operate, capable of extremely high accuracy and sensitivity, and has moderate maintenance requirements and low operating cost.

Induction-Alternator Type: The induction-alte-

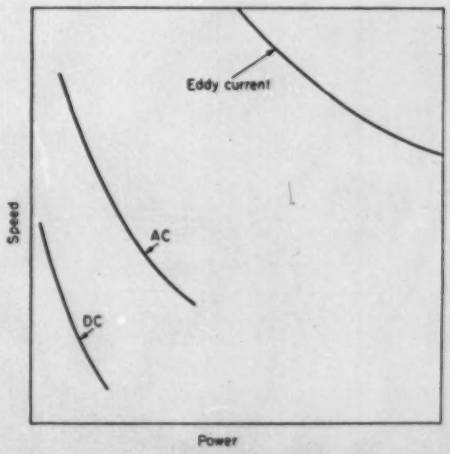


Fig. 1—Relationship of speed and power of three types of electric dynamometers.

nator type alternating-current dynamometer may be used for extremes of power and speed where some motoring capacity is required. Although it requires an adjustable-frequency motor-alternator set involving more complicated auxiliary equipment than the other types, the induction-alternator dynamometer is capable of high degrees of accuracy and sensitivity and will provide higher-speed motoring capacity than the direct-current dynamometer. The induction-alternator dynamometer is capable of moderate overloads and has a moderately low maintenance record.

Comparison of Types: The outstanding advantages and disadvantages of the various dynamometer systems are summarized in Table 1. Dynamometer ratings are not standardized by NEMA. Fig. 1 indicates relative areas of speed and horsepower for the three types of dynamometers.

Adaptability

To combine advantages of the various dynamometer systems, it is possible to combine types. For example, it is frequently desirable to build a direct-current and eddy-current dynamometer set. In this case, the former gives the motoring capacity for friction runs and the latter provides the greater capacity for absorbing total output. Control schemes for such combinations are devised to permit the direct-current and eddy-current dynamometers to absorb their proportionate share of the load during power-absorption runs.

Combination sets may also prove useful in increasing the flexibility of operation of both units individually or combined. Couplings have been developed which make it possible to mount two dynamometers in tandem so that the combined output may be utilized if necessary. When total output is not required, the coupling may be disengaged to permit individual use of either machine.

Extending Range: Gears may be employed in conjunction with dynamometers to increase torque and speed range to match the designer's needs. These gears may be used to extend the speed range by transmission type gearing or simply to increase the maximum speed through the use of set-up gearing. Gear losses may be calibrated to provide a minimum of measurement error, or gears may be cradled with the dynamometer system to eliminate any error which might be introduced by gear calibration.

Accuracy

The accuracy expected from dynamometer equipment depends to a very large degree on the condition of the equipment and the care and judgment exercised. Block-test type dynamometers are

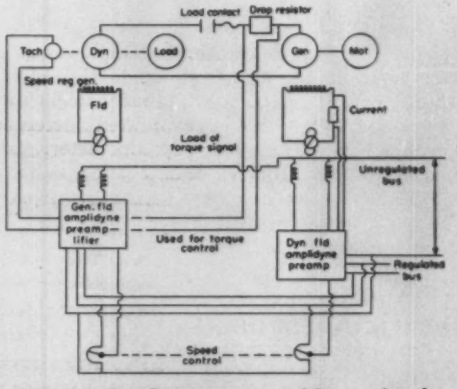
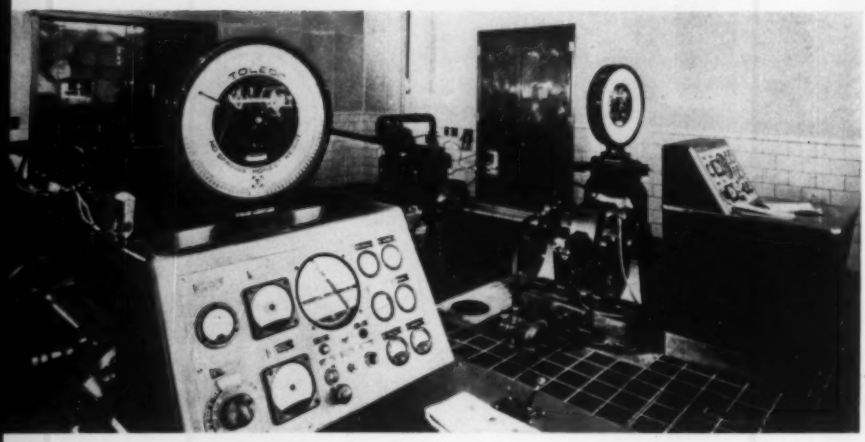


Fig. 2—Dc dynamometer with regulated electronic preamplifier amplidyne control.



Engine endurance test stand. View shows two 250-hp eddy-current dynamometers and operator's consoles.

normally calibrated so that torque may be measured with a maximum error of approximately 1 per cent.

In a cradled dynamometer the errors in measuring speed and horsepower depend to a large extent on the force and speed-measuring instruments supplied with the dynamometer. These same instruments are usually tailored around specific customer operational requirements. For this reason they are usually selected by the customer and supplied by the dynamometer builder.

Table 1—Comparison of Common Dynamometer Systems

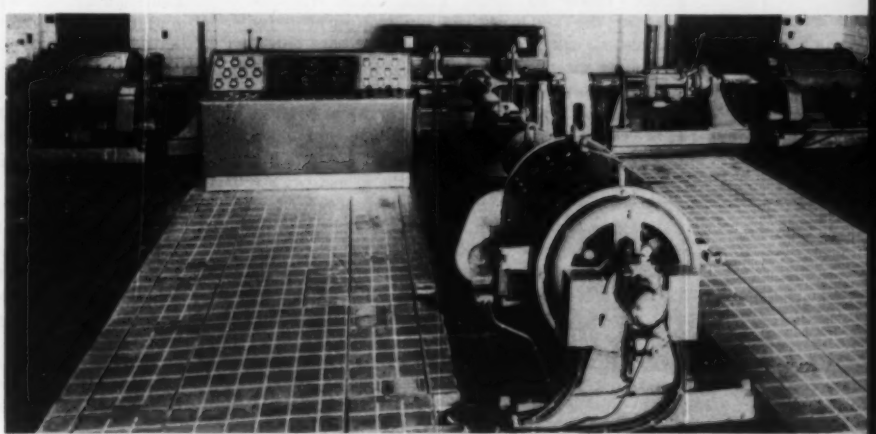
Dynamometer System	Advantages	Disadvantages
Eddy current	1. Low initial investment 2. Little auxiliary equipment required 3. Simple to operate 4. Small and compact 5. Rugged — will tolerate extreme overloads 6. Can be built for high power and speed 7. Reasonably high accuracy 8. Excellent mechanical stability	1. No motoring capacity 2. No recovery of power 3. Relatively poor torque characteristic at low speed 4. No torque at standstill 5. Relatively high maintenance
Direct current	1. May be used either motoring or generating 2. Operation very flexible and simple 3. Excellent low speed torque characteristic — motoring or generating 4. High torque capacity at standstill—motoring or generating 5. Economical operation — absorption capacity may be recovered 6. Capable of extremely high accuracy and sensitivity 7. Moderate maintenance	1. No appreciable overload capacity 2. No appreciable overspeed capacity 3. Larger than other types 4. High initial investment
Induction alternator	1. Can be built for extremely high speed —motoring or generating 2. Capable of moderate overloads 3. Moderately low maintenance 4. Economical operation — absorption power may be recovered 5. Capable of extremely high accuracy	1. Highest initial investment 2. System is somewhat complicated 3. Poor stall torque characteristics

In the cradle type dynamometer, the torque readings taken are normally on a scale or other type of force-weighing equipment and on a tachometer. Scales are available with various degrees of accuracy, the most common type of which has an error of approximately 0.1 per cent of the dial capacity.

Thus, the scale accuracy may be increased by using a smaller proportion of the total capacity on the scale dial and using resensitizing weights, added to the dial reading to obtain a total. It should be remembered that accuracy of the order of 0.1 per cent will be achieved with the scale in good condition. Dull knife edges, if used in the reverse torque linkages, or other sources of wear or friction in the scale or force mechanism, will increase error. Low-movement reversing-force cells are becoming increasingly popular since they eliminate high-maintenance knife edges.

A wide range of tachometer equipment is available for use with electric dynamometers. Many types give an approximate speed on a tachometer dial and provide for counting of revolutions over an elapsed time interval for more accurate measurement. In this case, speed measurement accuracy of approximately 2 revolutions during a 0.1-min time interval is normal. Electronic tachometer equipment is available which has a maximum error of 0.0001 per cent.

In addition to the errors introduced by the measuring instruments, other errors are inherent in the dynamometer itself. By knowing the source of these errors, the user can often correct for them or at least minimize their effect by taking proper precautions. Once the system is fixed, frequent calibration by standard weights and correction of faulty parts assures continued accuracy throughout the life of the equipment.



Axle test stand comprised of a 300-hp motoring dc dynamometer and two 250-hp absorption dc dynamometers connected through transmissions to the axle undergoing test. Input dynamometer is in the foreground and the gears, axle, absorption dynamometers and operator's console in the background.

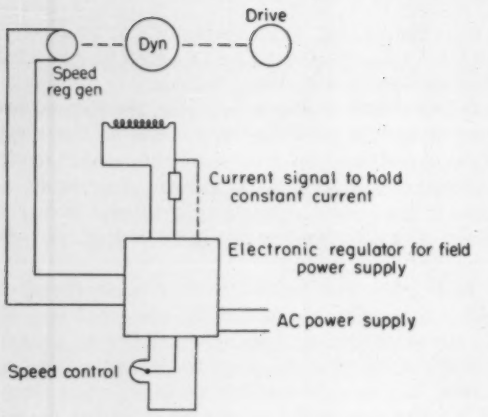


Fig. 3—Eddy-current dynamometer with regulated electronic control.

Sources of Error: Since the dynamometer principle depends on the entire reaction torque being transmitted to the force-measuring equipment, any connection to the dynamometer which is not reflected on the scale introduces an error. Since there are so many commonly used methods of connection and methods of supporting the dynamometer in the cradle, it is difficult to predict the error for which the electric dynamometer itself is responsible.

However, an error of approximately 0.15 per cent of its rated torque might be expected from a dynamometer which employs standard antifriction type trunnion bearings, rated current connections, and flexible oil or water connections. The principal sources of dynamometer error are summarized in Table 2.

Selecting Dynamometer Equipment

Recommended dynamometer systems for various types of testing are listed in Table 3. In addition to the basic equipment for dynamometer testing, they may be especially arranged, with appropriate

Table 2—Principal Sources of Dynamometer Error

1. **Service Connections**
   A torque error is introduced by making connections to the cradled dynamometer. Flexible connections for providing power to the dynamometer, oil and water connections, and similar service connections provide a torque error. These may be minimized by using mercury type contacts for electrical connections and long, flexible oil and water hose connections or by using null or very low-movement weighing systems.
2. **Windage**
   Windage errors in a cradle dynamometer are usually quite minor except for very high-speed dynamometers. Air which enters and leaves the dynamometer axially or radially with no tangential component introduces no error. Thus, when it is desirable to eliminate this minor source of error, guide vanes may be used at the air inlet and outlet and adjusted so that no tangential component of air enters or leaves the dynamometer.
3. **Cooling Water**
   In eddy-current type dynamometers, there is a small amount of reaction-torque error introduced when the water is pumped into the dynamometer under appreciable pressure. For this reason, water pressure is maintained as low as practical. In eddy-current type dynamometers which have the rotor surface solid and a toothed stator, cooling water is usually introduced into the air gap. Although minor, there is some unbalance of water on the two sides of the dynamometer, which introduces a torque.
4. **Auxiliary Equipment**
   Various dynamometer control systems require auxiliary power for operation. Such auxiliary power is usually taken from belt-driven tachometer generators which supply the feedback signal for the dynamometer control. This error can be eliminated by cradling the auxiliary equipment, particularly electric tachometers and feedback generators, with the dynamometer frame so that the reaction torque on the tachometers will be reflected on the dynamometer scale. Electric tachometers require practically no power from the dynamometer, so cradling does not represent an appreciable gain in accuracy.
5. **Trunnion Bearings**
   Probably the largest usual source of error in cradle dynamometers is in the trunnion bearings themselves. Dynamometer trunnion bearings are stationary under most conditions and therefore are subject to a very fast rate of brinelling. While not large on new equipment, this error increases during operation and is impossible to determine at any instant during the test. Hydrostatic-type journal bearings have been developed for this service, completely eliminating the trunnion bearing as a practical source of error. Dynamometers may employ devices for slowly rotating the outer races of the trunnion bearings to reduce the danger of brinelling. Means may also be used for rotating the outer races by hand to present a new bearing surface to the load.
6. **Tolerances and Expansion**
   Machining tolerances and thermal expansion can cause inaccurate determination of the actual lever-arm length, thus introducing a small dynamometer error.

Table 3—Selection of Type of Dynamometer

Equipment Tested	Dynamometer System	Advantages
Gears and axles	1. Dc geared input, dc geared output, motor-generator set 2. Dc geared input, eddy-current output, motor-generator set	1. High torque accuracy, versatile loading conditions 2. Low cost, high output torque without gears
Pumps, fans, blowers, compressors	1. Dc dynamometer, motor-generator set	1. High torque accuracy, versatile control
Electric motors and generators, development	1. Dc dynamometer (stall torque clutch), motor-generator set 2. Eddy current, stall torque clutch	1. High torque accuracy, versatile control 2. Low cost, high horsepower and speed capabilities
Electric motors and generators, production	1. Eddy current dynamometer	1. Low cost, fast testing, simple control
Auto and truck chassis	1. Dc dynamometer, chassis rolls motor-generator set 2. Eddy current, chassis rolls	1. High torque accuracy, versatile loading 2. Low cost
Reciprocating engines, development	1. Dc dynamometer and motor-generator set	1. Motoring ability, highest torque accuracy, accurate control
Reciprocating engines, endurance	1. Eddy current dynamometer	1. Low cost, good accuracy
Torque converters, development	1. Dc input, dc output (with stall torque clutch) motor-generator set 2. Dc input, eddy-current output motor-generator set	1. High torque accuracy, motor from either end, accurate control 2. Lower cost, higher output torque capacity for given top speed
Torque converter transmissions, endurance	1. Engine input, eddy-current output, flywheel for inertia	1. Duplicates service conditions, low cost
Torque converter transmissions, production	1. Dc input, block-test eddy-current output with stall torque device and flywheel, motor-generator set 2. Engine input, block-test eddy-current output with stall torque device	1. Low cost, convenient 2. Lowest cost

control equipment, to accommodate a variety of testing needs. Typical is the transmission-testing equipment which provides for torque and speed control on the input and output dynamometer equipment. This may be arranged so that torque may be kept constant on the input and speed constant at the output or vice versa. Such auxiliary equipment as is necessary for this type of test greatly simplifies the testing procedure and relieves the testing personnel of the bulk of critical control of the equipment.

Control circuits can be arranged to suit requirements of cost, versatility, and performance.

DC System: A partial schematic of a typical dc dynamometer control system is shown in Fig. 2. This system can be used for either regulating speed or torque, but of course not simultaneously. The speed signal comes from a small dc generator which is driven by the dynamometer. The dc generator's voltage is proportional to speed. The current signal comes from an armature-circuit dropping resistor which has a voltage drop proportional to current. In either case the dc signal is compared to a selected regulated signal, and the error is amplified and controls an amplidyne field which in turn adjusts the generator field.

A current-limit field and over-voltage protection is also used to protect the system from damaging currents or voltage. Since the speed signal is much greater than the current signal and both operate in the same regulating system, speed is controlled more accurately than torque. The dynamometer field is regulated so that field current does not

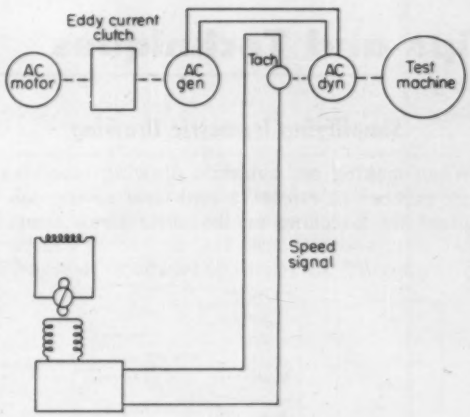
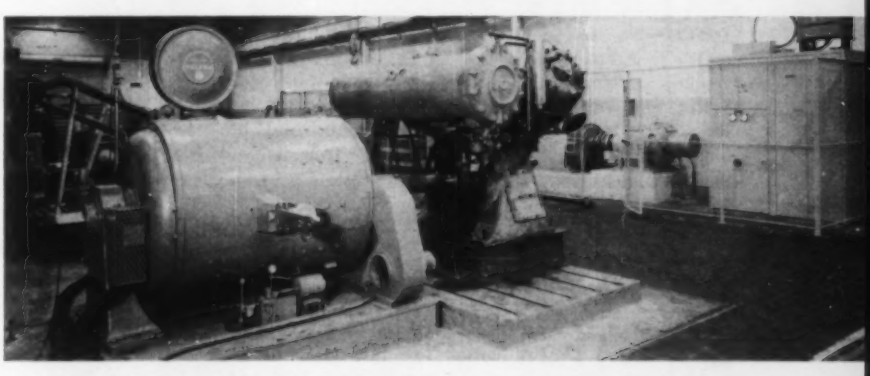


Fig. 4—Ac dynamometer with amplidyne regulated speed control.



Direct - current dynamometer coupled to compressor. In background is a 250-kw motor-generator providing power for dynamometer.

change with temperature; in this way armature current regulation results in torque regulation.

Eddy-Current System: A partial schematic of an electronic regulated eddy-current dynamometer system is shown in Fig. 3. Speed control is obtained by matching the signal of a small dc generator that is driven from the dynamometer to a selected bus-regulated speed signal.

The error signal is then amplified and controls an electronic power supply for the dynamometer field. An approximate torque control is obtained by controlling the eddy-current field to a constant current value.

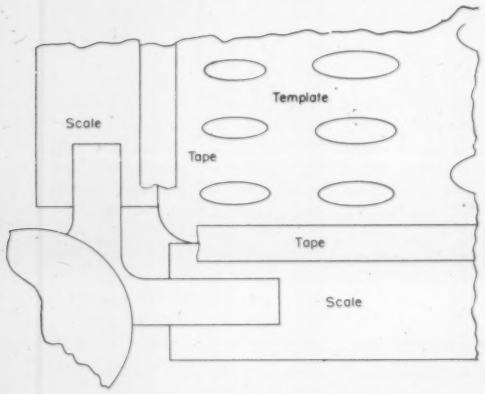
AC System: The ac dynamometer control of speed utilizes the same sensing and amplifying scheme as the dc and eddy-current system, but it is used to excite the field of the eddy-current clutch between the ac motor and the ac generator. This control of the field in turn controls clutch slippage and therefore the frequency of the ac generator. Fig. 4 illustrates the control diagram for the ac dynamometer system.

Program testing arrangements may also be worked out with electric dynamometer equipment. Typical tests of this nature involve setting up a complicated test manually with the pertinent electrical parameters recorded on magnetic tape. When played back, the magnetic tape will automatically cycle the test equipment through any number of predetermined identical cycles. As an example, special cycling equipment for testing completed vehicles has reduced the need for outdoor examination. Dynamometer stands may be employed with large drums which transmit the power from a vehicle to the dynamometer. Adjustable inertia equipment, either mechanical or by electrical simulation, may also be coupled to the dynamometer shaft to facilitate acceleration and deceleration tests. Thus, complete vehicles may be tested by dynamometer equipment which simulates steady-state conditions, grade, windage, and inertia of the vehicle as it accelerates and decelerates, permitting complete examination of the vehicle under controlled conditions.

Tips and Techniques

Simplifying Isometric Drawing

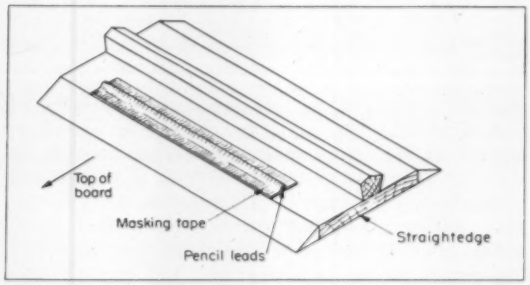
When making an isometric drawing involving a large number of circles, a real time saving can be realized by fastening an isometric circle template



to the drafting machine with masking tape as shown. The template is always handy and may be quickly and accurately positioned for use.—BERTON J. LEAVITT, *Cushman Motor Works, Lincoln, Neb.*

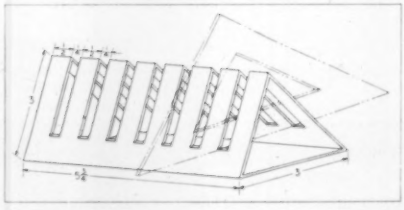
Straightedge Tray

A simple "tray" can be constructed on a straightedge to retain pencils which are laid there. The tray consists of a number of pencil leads laid end



to end and retained by masking tape.—LAXMI NAGAICH, *Dayton, Ohio.*

Drawing Instrument Holder



A simple instrument holder can be constructed from 1/16-in. Plexiglas or other suitable material. Slots are cut to hold triangles, curves, and templates. Dimensions given have been found useful, but may be altered to suit. — RICHARD KNOTT, *Motor Wheel Corp., Duo-Therm Div., Lansing, Mich.*

FINDING AREAS

with Simpson's rule and auxiliary ordinates

By M. Deha Korkut, *Harvey, La.*

AREA under a curve may be found by a method of approximate integration involving Simpson's rule and auxiliary ordinates. Simpson's first formula for area is

$$A = \frac{(\Delta x)}{3}\,(y_0 + 4y_1 + 2y_2 + \ldots + 4y_{n-1} + y_n)$$

where the curve is described on rectangular coordinates x and y, and Δx represents unit interval; i.e., its interval value is equal to one. This formula is used for an even number of equal intervals of an area. The expression $(\Delta x)/3$ equals the total length along the x-axis divided by the sum of coefficients of ordinates:

$$\frac{(\Delta x)}{3} = \frac{\text{Length}}{\text{Sum of coefficients}}$$

The term in parentheses in the first equation is often called the *area function*. The area function simply means that coefficients of even-numbered ordinates of intervals are the totals of left and right interval values, and uneven numbers will be doubled, Fig. 1.

Adding Auxiliary Ordinates: Where a curve is irregular, auxiliary ordinates can be added, to form groups of even numbers of intervals of equal value, with long intervals where the curve is relatively smooth, and short intervals where the curve is irregular. Fig. 2 shows an area of five unit intervals. Shape of the curve is such that additional ordinates are located at ½, 3 1/3, 3 2/3, 4 1/3 and 4 2/3. Thus, in this case, if $y_{1/2}$, $y_{3\,1/3}$, $y_{4\,1/3}$ are considered uneven-numbered ordinates and $y_{2/3}$, $y_{4\,2/3}$ even-numbered ordinates, using the notion of area function leads to the following table:

Ordinate Location	Internal Values	Resulting Coefficients
0		1/2
	1/2	
1/2		2
	1/2	
1		1 1/2
	1	
2		4
	1	
3		4/3
	1/3	
3 1/3		4/3
	1/3	
3 2/3		2/3
	1/3	
4		4/3
	1/3	
4 1/3		2/3
	1/3	
4 2/3		4/3
	1/3	
5		1/3

If the coefficients are correct, length divided by sum of coefficients must be equal to $(\Delta x)/3$, as described earlier. In this case, length equals $5(\Delta x)$ and sum of coefficients equals 15. Therefore,

$$\frac{5(\Delta x)}{15} = \frac{(\Delta x)}{3}$$

Then, area between y_0 and y_5 becomes

$$A = \frac{(\Delta x)}{3}\left(\frac{y_0}{2} + 2y_{1/2} + \frac{3y_1}{2} + 4y_2 + \frac{4y_3}{3} + \frac{4y_{3\,1/3}}{3} + \frac{2y_{3\,2/3}}{3} + \frac{4y_4}{3} + \frac{2y_{4\,1/3}}{3} + \frac{4y_{4\,2/3}}{3} + \frac{y_5}{3}\right)$$

If Simpson's formula were applied separately to find areas limited by individual groups of original or auxiliary ordinates, the total area would be represented by the foregoing form.

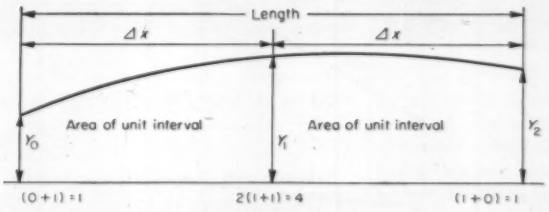


Fig. 1 — Above — Division of a simple curve for areas of unit interval.

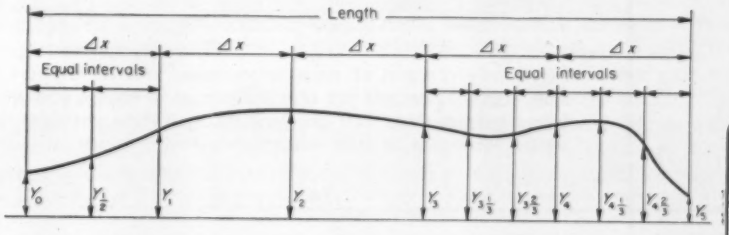


Fig. 2—Right—Division of an irregular curve having five unit intervals with auxiliary ordinates.

Factors affecting the strength of

Sintered Steel Parts

By Robert Talmage
Consultant
Burgess-Norton Mfg. Co.
Geneva, Ill.

PARTS produced by the powder metallurgy process have a much wider range of physical characteristics and properties than parts produced by other metallurgical methods. Sintered steel parts exhibit properties equivalent to normal wrought steel in almost any analysis and are more uniform in structure because of close control of raw materials.

Economics is a major factor in the choice of materials and methods for production of sintered steel parts. In general, the mechanical properties and cost of sintered steel vary directly with density. The method can always save money if parts can be processed in only one pressing and sintering. It is best for design engineers to determine the mechanical properties actually required for each part in an application and specify these properties in obtaining parts for test and production.

Two important concepts are associated with powder metal techniques:

1. The usable strength of a metal can be developed after its shaping operation, whereas in ordinary metallurgy it is always developed before or during the shaping operation.
2. Density is a new variable physical property just as the amount of cold work or stress is a variable physical property in wrought metal products.

Because of thinking habits associated with casting metallurgy, it is felt that close control of raw powders entering a mixture is of primary importance and that sintering control is of secondary importance. Actually, the opposite is true. High-strength parts can be produced from any standard iron powder, but low strength parts can easily result from poor sintering.

Fig. 1 shows how time, temperature and atmosphere affect the strength of average-density, plain-carbon, sintered-steel parts. The 0.1 per cent carbon content ma-

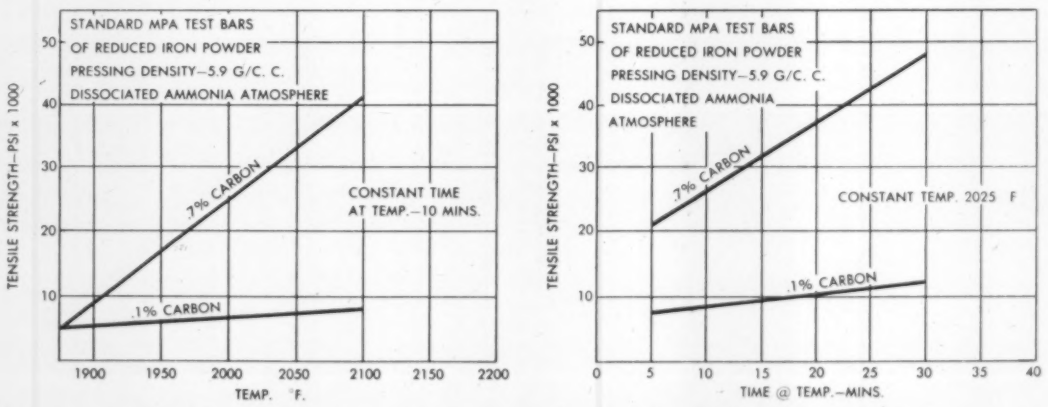


Fig. 1—Left, effect of time, temperature and atmosphere on plain carbon, sintered steel parts. The 300 per cent difference in tensile strength compares to an approximate gain of only 100 per cent in equivalent wrought steels. Right, sensitivity of tensile strengths to time-temperature relationships with addition of graphite.

terial is obtained by sintering a 5.9 grams/cu cm density MPA tensile bar briquette of standard reduced iron powder with 1.0 per cent zinc stearate added as a lubricant. The 0.7 per cent carbon material is of exactly the same composition except that 1.0 per cent of fine graphite powder is added to the mixture. The additional combined carbon is obtained by diffusion during sintering. Most continuous production furnaces sinter for about 10 minutes at a maximum work temperature of about 2025 F. Under normal sintering conditions at this time and temperature, a 300 per cent difference in tensile strengths between the 0.1 and 0.7 per cent carbon content materials results. This compares to an approximate gain of only 100 per cent in equivalent wrought steels.

Fig. 1 also shows how much more sensitive the tensile strength is to time - temperature relationships when graphite is added. Rather wide ranges of time-temperature have comparatively little effect on values obtained from low-carbon sintered steel, but the same ranges of time-temperature produce great changes on those with graphite added. The importance of good atmosphere conditions is also evident in Fig. 1. One of the most common problems in sintering is maintaining a high carbon potential atmosphere. If excessive decarburization takes place, the possible tensile strength is reduced to something approaching that shown for 0.1 per cent carbon content material. Most of the advantage of graphite additions is thus eliminated.

Proper selection of raw materials for alloying additions is important in producing high-strength parts. There is a very wide choice of grades and types of graphite which can be used, but only a relatively few will give the best results. It is also true that best results are obtained with better quality graphite powders.

Variable Density: Density, with its counterpart porosity, is controlled by the briquetting process and is particularly important to the successful production of high-strength parts. It is varied by the amount of pressure applied during briquetting, and its variability is

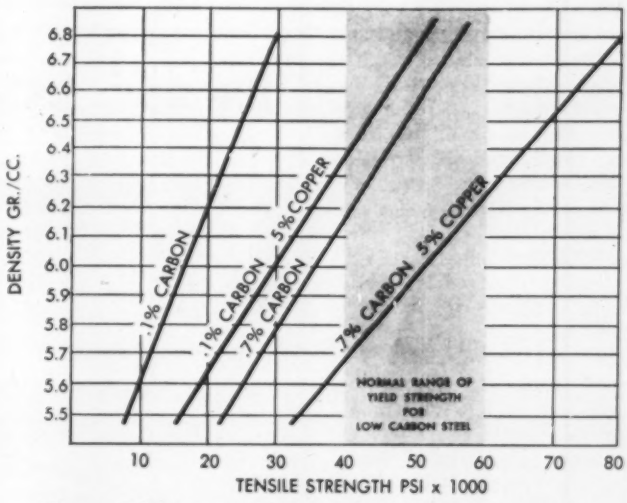


Fig. 2—Effect on tensile strength of low-carbon material by addition of copper and carbon. Curves show ultimate tensile strength values.

a distinct advantage of sintered steel. The ability of such porosity to be impregnated with a wide variety of metallic and nonmetallic materials offers many totally new approaches to the solution of metallurgical problems such as wear, noise, weight, heat and conductivity. For example, impregnation of hardened steel with a lubricating oil reduces wear of roller chain by as much as 80 per cent. Also, impregnation with viscous materials increases resonant damping qualities to reduce noise and to change fatigue characteristics. Porosity also permits many new combinations of metals with totally new physical properties.

The influence of variable density on the strength of sintered steel is so great that, even under the best of sintering conditions, tensile strengths of 70 per cent less than the maximum obtainable are possible if density is not as it should be. Despite this difference, most sintered parts drawings do not specify density even after approval of samples.

Sintered Steel in Design: It is seldom necessary to duplicate exactly mechanical properties of wrought steel when sintered steel is substituted. Wrought steel has much greater ductility than most sintered steels. This property, however, has relatively little value in the performance of a gear, for example, since even a slightly bent tooth will prevent proper functioning of the mechanism. Good ductility is often required when severe bending or drawing operations are necessary, but it should be remembered that these operations are seldom performed on sintered steel parts because of the much wider range of shapes possible initially.

In many cases of substitution, duplicating values of usable strength in sintered steel is all that is necessary to obtain equivalent strength in an application. This is not difficult to do with just basic operations because carbon and copper, for example, combine quickly and uniformly by diffusion in iron at normal sintering temperatures. The resultant high-carbon, high-copper alloy is relatively unknown in "liquid" metallurgy because of manufacturing difficulties.

To illustrate the strength advantage of this relatively new alloy, Fig. 2 shows the density-tensile strength relationship of four related materials. These curves were drawn from data obtained from testing standard 0.200-in. thick MPA tensile bars briquetted and

sintered under production conditions to obtain actual production values. The curves show the ultimate tensile strength values. In high-carbon materials there is very little elongation so, for all practical purposes, yield strengths are the same. The lower limit of density is approximately 5.5 grams/cu cm which is about the practical limit for a satisfactory material. Values of density close to 5.0 could possibly be produced.

It can be seen how much strength the copper and carbon add to the low-carbon material, particularly when both are used. When compared to the yield strength of low-carbon steel, the figure easily brackets the normal figures and can exceed them. Even at relatively low densities, the figure is fairly good. However, these values are obtainable only under good sintering conditions. If the atmosphere is improper and the time at temperature insufficient, the strength can be reduced by as much as 75 per cent. In actual practice, however, it has not been found difficult to control these variables to insure uniformly high strengths.

Cost Factors: It should be emphasized that designers should not specify a higher density than is adequate for the use intended. It is fundamental that the cost of production increases as density increases because of higher material and manufacturing costs. Fig. 3 shows why manufacturing costs increase with density. Pressure required for briquetting accelerates rapidly as the density increases. It is not possible to obtain a density more than 6.8 grams/cu cm with this particular powder mixture. Any pressure beyond approximately 55 tons/sq in. does not accomplish further compression. Such high pressures necessitate special considerations in tooling and pressing which result in high tool costs, greater tool wear and maintenance, greater risk to tools, and larger presses.

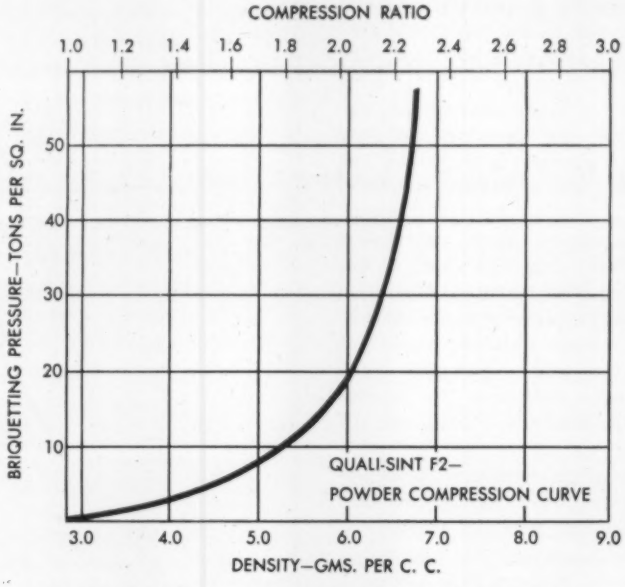


Fig. 3—Briquetting pressure-density relationship. Manufacturing costs increase with density because of special considerations in tooling wear and maintenance as a result of applying upper-limit pressures.

From a paper entitled "Primary Considerations in the Design and Use of Sintered Metal Parts" presented at the Annual Meeting of the Metal Powder Association in Chicago, April, 1957.

Adapting design practices to

Thermoplastic Materials

By Victor S. Bowers

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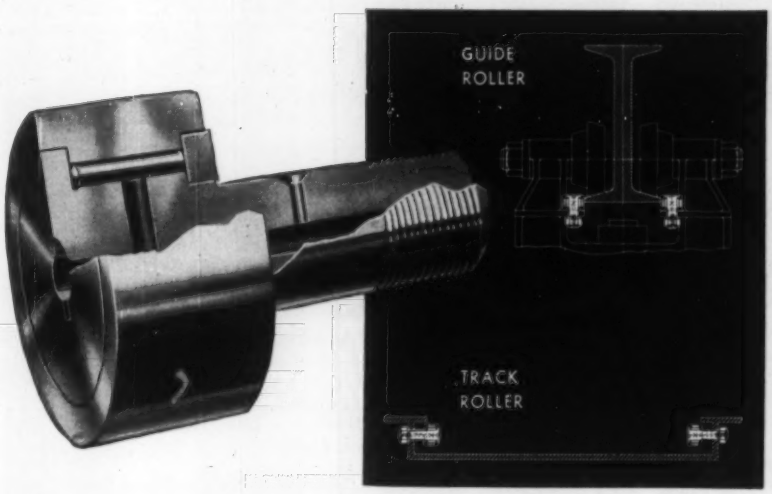
BECAUSE the term *plastics* covers such a wide field, design comments are aimed at a nylon resin, Zytel. However, the engineering principles are applicable to all other thermoplastic materials.

Design Procedures: In general, the same design considerations that apply to metal die castings can also be applied to plastic parts. Following are the exceptions:

1. Plastic parts can be designed and produced with wall sections as thin as 0.015-in. Thus, parts can be designed for the minimum thickness of sections required. This results in economical use of material and volume production due to rapid heat transfer from polymer to die surfaces.
2. Inserts are easily accommodated in plastic moldings. Because most plastics do not react chemically with any of the metals, any type of insert is suitable.
3. The major difference between plastic molding and die casting is that there is usually no flash on a well-designed plastic mold. Cold wells are seldom necessary. The part is ready for use as it comes from the mold, and trimming or finishing is not necessary. Mold finish is duplicated

BEARING TIPS by McGill

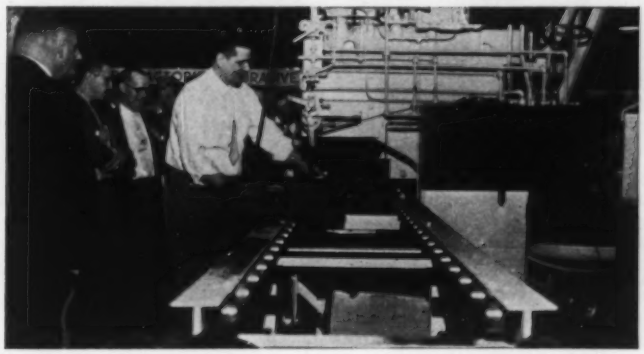
Let a CAMROL bearing be your guide



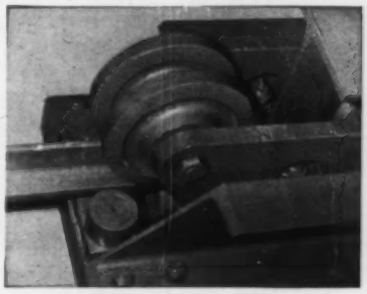
Obtain freer rolling, improved alignment and positive side thrust

In guide and support roller applications CAMROL Cam Followers insure free rolling action and positive side thrust while eliminating the wear of more costly flanged wheels. Then, too, they provide improved alignment and low starting and running friction with high unit load and shock capacity, especially at low speeds as track rollers. Lubrication is simplified and maintenance can be reduced to a minimum in these applications. Specify the interchangeable sealed SGR series for added protection against contamination.

CAMROL CF bearings provide friction-free track rollers for automatic mold blower



McGill CAMROL CF rollers are used as guide rollers to form a mold conveyor in the Beardsley & Piper MBS-20 Mold Blower. The machine blows and squeezes cope or drag in a single automatic operation, handling up to 4 molds per minute. The CAMROL CF bearings replaced less efficient friction rollers in this application. Although, the duty here is rather light and speeds slow, the cam follower bearing provides lesser starting and running friction. This helps speed the flow of work from the machine, which must be fast and automatic. The integral stud feature eases assembly and its standard design simplifies procurement.



CF bearings minimize maintenance as crane side guide rollers

McGill CF cam follower bearings serve as side guide rollers in overhead cranes manufactured by Louden Machinery Company of Fairfield, Iowa. Freedom from maintenance, a time saver because of the inaccessibility of the bearing when the crane is in operation, is an important advantage of the cam follower bearing.

Send for Catalog No. 52-A

Insure performance with McGILL®

MULTIROL® GUIDEROL® CAMROL®
Precision Needle Bearings

McGILL MANUFACTURING COMPANY, INC., 200 N. LAFAYETTE ST., VALPARAISO, INDIANA

Circle 457 on page 19

exactly on the plastic parts.

Design factors normally considered in metal die castings, i.e., bosses, ribs, fillets, draft, parting lines, undercuts, holes, etc., are handled in the same manner when designing for plastics. The same formulas and general approach are used with plastics as with other materials of engineering.

Design Data: A typical tensile stress-strain curve for Zytel 101 is shown in Fig. 1. Note that the yield point in thermoplastic materials is much higher above the proportional limit than it is in ferrous metals. Also, the elongation prior to failure is greater for plastic materials than for ferrous metals.

Common strength - of - material formulas are used in design calculations for plastics. Formula values are obtained from published data, and safety factors are applied for plastics just as they are for metals. Design stress is obtained by dividing the yield strength of the material by the safety factor which, for plastics, varies from three to ten.

Many physical values used in design calculations are influenced by environment. Whether the designer is concerned with metals or plastics, the successful operation of the part will depend largely on how well it is designed to accept its environment.

The effect of temperature relative to expansion and contraction is more pronounced in all thermoplastic materials, but again, the calculations used to predict dimensional changes are exactly the same as those for designing with metals. The coefficient of thermal expansion for Zytel is approximately eight times that of carbon steel. In the production of dimensionally accurate parts, this is an important property to consider.

The tensile strength of this nylon resin decreases with an increase in temperature and/or moisture. Nylon will absorb moisture from its environment up to 2½ per cent by weight at 73 F and 50 per cent relative humidity. When submerged, it will absorb up to 8½ per cent moisture by weight. The designer should select a tensile strength that will produce an adequate design for environmental conditions encountered in actual practice.

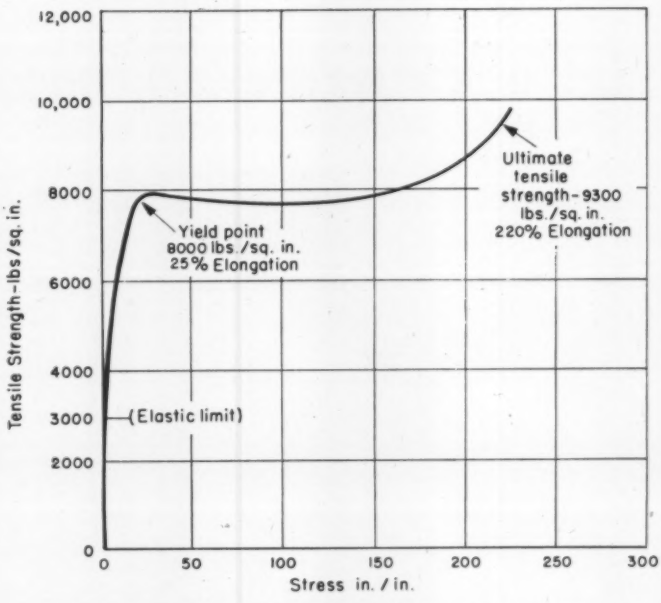


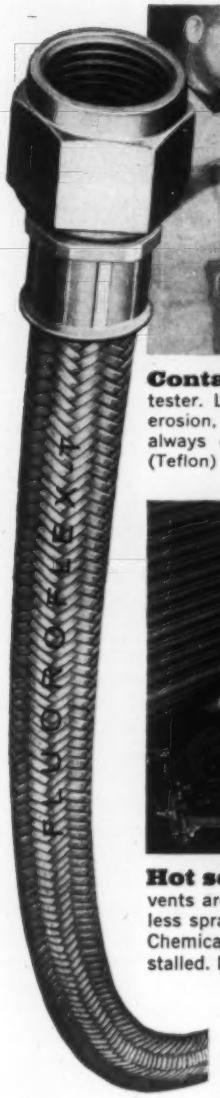
Fig. 1—Tensile stress-strain curve for Zytel 101, a nylon resin.

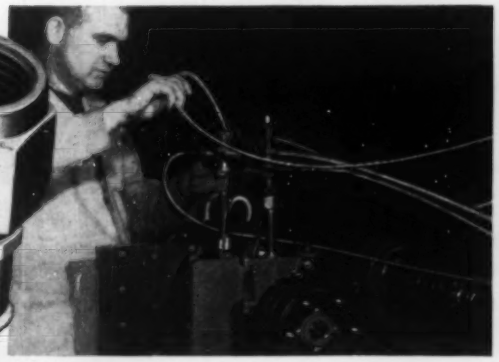
Modulus of elasticity decreases with an increase in moisture content and temperature which affect the dimensions of the part. To establish final dimensions, the designer must make allowance for moisture pickup. Since molding practice dictates that powders contain less than 0.3 per cent moisture by weight, it is obvious that the molded and relatively dry part will absorb moisture until it reaches equilibrium. Since this is a surface phenomenon, the rate at which absorption occurs depends on the thickness of the part, the temperature and moisture availability.

Molded plastic parts contain stresses much the same as molded or die cast metal parts and must be annealed or stress relieved when dimensional stability is important. Parts can be annealed by immersing in a high-boiling liquid heated to 300 F. Immersion time should be equivalent to 15 minutes for each ⅛-in. thickness. Annealing, when required, is done by the molder and should be specified on the drawing of the part to be molded.

Creep, or deformation with time, occurs in all plastic materials. Designers using ferrous metals generally are not concerned with the problems of creep except at elevated temperatures. However, this phenomenon occurs in plastics at room temperatures and must be considered when deformation with time might cause failure of the part. It has been shown in studies of Zytel at various stress levels that, below the proportional limits, the magnitude of deformation under a given stress is essentially the same whether under tension or compression. When a stress is applied, there is an elastic deformation up to the proportional limit. A period of transitory deformation then occurs ending at approximately 100 hours or less. Beyond this point, the deformation is represented by essentially a straight line function of time. The total amount of deformation at the end of 24 hours will be approximately 75 per cent of that obtained at the end of one year. Creep after one year is so small that for all practical purposes of design it can be neglected.

Do you have any of these flexible hose problems?

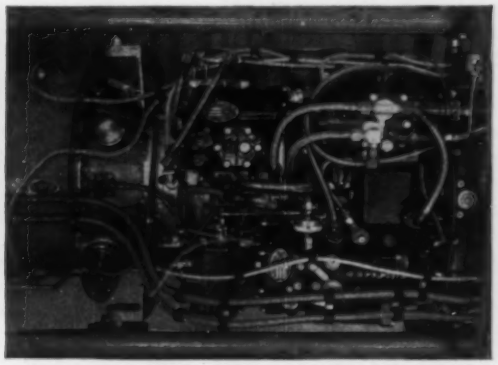




Contamination. This is a hydraulic equipment tester. Lines used previously contaminated the oil by erosion, required excessive replacement. Now fluid is always clean because chemically inert Fluoroflex-T (Teflon) hose assemblies neither corrode nor erode.

Excessive flexing. Ordinary hose on a plastic molding press, subjected to heat plus constant flexing on 50-second cycle 22½ hours a day, lasted three months. Then Fluoroflex-T (Teflon) hose assemblies were tried. Even after three years, there were no failures.

Hot solvents. Finishes using strong organic solvents are sprayed hot at 500 to 600 psi with this airless spray equipment. Ordinary hose failed frequently. Chemically inert Fluoroflex-T hose assemblies were installed. Record shows no failures after 2 years service. *(Photo courtesy Bede Products, Inc.)*



High temperature. While conveying active fuels and oils, the plumbing of a jet engine is also exposed to high temperatures. Ordinary hose fails fast in this service. Fluoroflex-T hose assemblies have now had over 4 years of flight service, are specified for virtually every jet engine.

Most flexible hose problems are quickly solved for good by Fluoroflex®-T hose assemblies with the original, patented Teflon® tube. Consider these qualifications: non-aging; completely inert; flexible over entire continuous operating range of −65°F to +450°F; lightweight; small O.D.; 1000 psi working pressures; stainless steel outer braid; and blowoff-proof fittings. Send for data.

® Teflon: DuPont trademark. Fluoroflex: Resistoflex trademark.

RESISTOFLEX CORPORATION, Roseland, N. J.
Western Plant: Burbank, Calif. • Southwestern Plant: Dallas, Tex.

20th year of service to industry

Resistoflex

Fluoroflex-T industrial hose and assemblies are available from leading distributors — write for names.

Zytel 101 conditioned at 73 F and 50 per cent relative humidity initially, has a modulus of 200,000 psi. After 100 hours, the apparent modulus is 114,000 psi, and in one year has reached an almost constant value of 90,000 psi.

Fabrication: With most plastics, fabrication methods are limited only by the designer's imagination. Many plastics can be cemented together and many can be heat welded in a manner similar to gas welding metals.

Spin welding, or friction welding, is applicable to production techniques. In this method, one member is rotated against the other and enough frictional heat is generated to melt the plastic. Another joining technique is to use a metallic insert between two plastic parts and heat the insert by induction. The insert melts the surrounding plastic causing fusion of the parts. Almost all mechanical methods of joining are applicable to most plastics.

From a paper entitled "Designing with Plastics" presented at the 14th Annual Machine Design Conference held at the Cleveland Engineering Society, March, 1957.

Three-Dimensional Drafting

By Paul F. Boehm

Technical Consultant
John R. Cassell Co., Inc.
New York

ENGINEERING drawings should be understandable without words as comments. As long as various objects are comparatively simple in shape and composition, conventional blueprints serve the purpose.

However, the situation is changing in a significant way; objects of engineering drawings are becoming more and more complex. It is becoming harder to read and understand drawings. Also, there is less time and opportunity for training potential readers of the engineer's picture language to enable them to understand more complex drawings. Hence, the existing difficulties in communicating ideas through conventional drawings.

Three-dimensional illustration serves as easy communication of ideas to parties not trained in reading orthographic drawings. Various types of 3-D illustration are available. A highly practical procedure has been adapted with success. Wherever the standard blueprint does not convey to the user at first glance the concept of the illustrated structure, a one-view, 3-D picture is added to the corner of the drawing as a supplement. It serves as an explanatory comment and helps to interpret the drawing correctly.

Three-dimensional drawings show three main faces of an object which otherwise would be shown by a three-view projection. A second one-view picture may be added if the opposite three faces comprise features that cannot be shown well in dotted lines in the first view. Thus, the three-view method replaces up to six projections in the conventional layout. Dimensioning and sectioning are done in exactly the same manner as conventional orthographic projections.

There is one field in which 3-D illustration has established itself as a standard vehicle of communication of engineering ideas: the mutual relation of elements of a multipart assembly is comprehensively shown by exploded assemblies. Tests have shown that it takes about half the time to make a 3-D drawing than it takes to draw corresponding orthographic projections. In three-view drawing, each element must be shown at least twice. There is a continuous duplication of work throughout the process. With the one-view, 3-D method every element of the drawing occurs only once in one view. Substantial additional advantages are derived by adopting the 3-D method as a standard drafting practice. By representing an object in one view, about half the paper area is required. Size and cost of blueprints and photostats are cut in half and handling and storage become easier.

The closest resemblance between object and drawing is obtained by using true perspective. However, the method is rather complicated and is not recommended for general purposes as a drafting method.

A comparatively simple type of 3-D illustration, and one which is scalable, is oblique projection. Two types of oblique projection are in use: cavalier projection and cabinet drawing.

A type of 3-D illustration particularly suited for one-view drawings is axonometric projection, actually a different application of orthographic projection. The difference is that the object is not oriented with one of its principal faces parallel with the picture plane. The result is a one-view, 3-D projection which is entirely to scale but otherwise similar to a pleasantly natural perspective. An unlimited number of possibilities of orienting objects exists within the realm of axonometric projection. These possibilities depend on the amount of rotation around the two axes applied to the object.

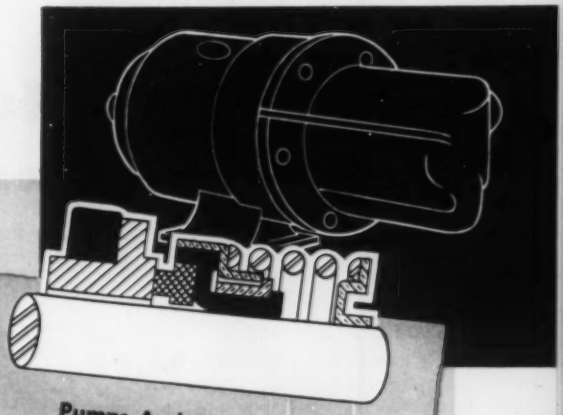
Three groups constitute the family or projections called the axonometric system: the isometric, dimetric and trimetric groups. Isometric often fails to illustrate properly and pleasantly certain configurations occurring frequently in mechanical drawing and takes more space than dimetric drawings do.

Dimetric drawing is superior to isometric and well worth the trouble of using two scales and two types of ellipses. Difficulties arising in isometric from conditions of symmetry are greatly reduced or eliminated. Dimetric allows the choice of turning the object either to the right or left.

From a paper entitled "Triple Plane Approach to Design" presented at the 14th Annual Machine Design Conference held at the Cleveland Engineering Society, March, 1957.

Machine Tools And Power Transmission Equipment

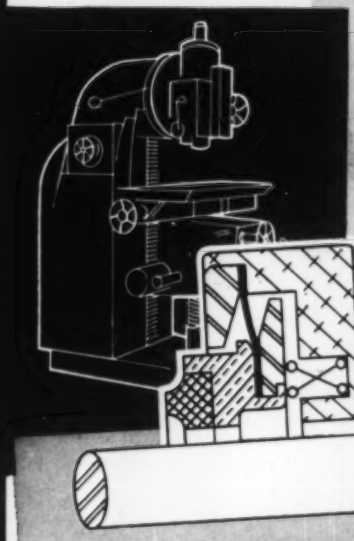
STYLE GU — A packaged sealing unit containing both rotating and stationary seal faces enclosed in metal housing. Stock sizes for shafts .250 through 4.000.



Pumps And Compressors

ROTO-FLEX — Rugged flexibility. Only 3 parts. Single or double units. Stock sizes for shafts .250 through 4.000.

STYLE RFO — A specially designed Roto-flex seal, for installation outside the stuffing box. Stock sizes for shafts .250 through 4.000.



Heavy Machine Tools

STYLE DPC — A high-speed, carbon-faced seal, for more compact installation in heavy industrial machinery. Stock sizes for shafts .250 through 4.000.

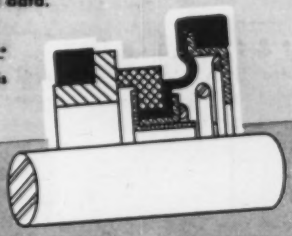
A Complete Line GITS SHAFT SEALS For Every Application

These modern, mechanical, face-type seals are carried in stock — to save you time and money. Write for detailed data.

GITS BROS. MFG. CO.

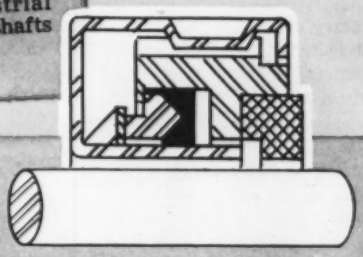
1868-A South Kilbourn Avenue • Chicago 23, Illinois

Specialists In Lubricating Devices And Shaft Seals For Almost Half-A-Century



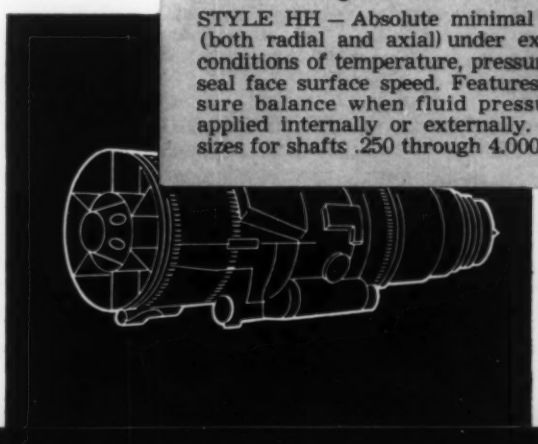
Household Appliances

STYLE SGU—A factory-assembled unit-type seal for the small-budget user. Stock sizes for shafts .250 through 1.000.



Aircraft Engines And Accessories

STYLE HH — Absolute minimal space (both radial and axial) under extreme conditions of temperature, pressure and seal face surface speed. Features pressure balance when fluid pressure is applied internally or externally. Stock sizes for shafts .250 through 4.000.



Circle 459 on page 19

Helpful Literature
for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Carbon Brushes

Comprehensive brochure 18A on carbon brushes covers brush characteristics, grades and applications, NEMA standards, brush and commutator maintenance, Karak carbon products and carbon specialties. Karak products include rings, seals, plates, specialties and contacts. Ordering forms are provided. 52 pages. Ohio Carbon Co.

Circle 550 on page 19

Electric Thermostat

Model H1 electric thermostat for steam generating systems, ovens and other industrial equipment will cut out where dialed temperature is exceeded by 15° F in liquids or 30° F in air. Bulletin RT-805 describes this unit, offered in ranges to 800° F. 4 pages. Robertshaw-Fulton Controls Co.

Circle 551 on page 19

Heat & Pressure Controls

More than 34 basic types of industrial temperature and pressure controls are listed in this general catalog. Included are self-operating regulators, water mixing equipment, pneumatic control instruments, indicating and recording instruments, control valves and pneumatic motors. 96 pages. Powers Regulator Co.

Circle 552 on page 19

Acrylic Sheet Plastic

"Fabrication Data of Cadco Extruded Acrylic Sheets" is title of bulletin EX-101 providing information on handling, machining, forming, cementing and annealing of low-cost Cadco extruded acrylic sheets. Property tables and light transmittance charts, including comparison with cast sheet, are provided. 12 pages. Cadillac Plastic & Chemical Co.

Circle 553 on page 19

Electronic Data Processing

Details of the completely transistorized type S-2000 Transac computer are given in illustrated catalog. Compactness, light weight, low power consumption and reliability are features of this electronic digital computer. Memory capacity is 4096 words, expansible to 65,536 words. 12 pages. Philco Corp., Government & Industrial Div.

Circle 554 on page 19

Magnets

Magnetic properties of three types of ferrite materials are described in series of three data sheets. These Ferramic O-2, Q and H materials are used as component parts in radio and TV sets, computers, automatic controls and electronic equipment. 2 pages each. General Ceramics Corp.

Circle 555 on page 19

Oscillographs

Oscillographic recorders, consoles and amplifiers are subject of bulletin GC-5. These completely redesigned units are used for recording physiological, mechanical and electrical phenomena. 4 pages. Edin Co.

Circle 556 on page 19

Equipment Cooling Blowers

"What We Make" is title of illustrated brochure that describes various sizes and types of fans and blowers designed specifically for cooling of such equipment as missiles and rockets, computer and radio equipment, military and marine installations, and industrial and instrumentation products. Bulletin 10101-1A. 8 pages. Rotron Mfg. Co.

Circle 557 on page 19

Heat Treating & Processing

A pictorial story of the equipment and facilities of this company is presented in booklet entitled "Specialized Equipment and Skills Devoted Exclusively to the Heat Treatment and Processing of Metals." Included are a glossary of heat treating terms and a series of applicable engineering tables. 32 pages. Commercial Heat Treating Co.

Circle 558 on page 19

Stainless Steel

"An Introduction to U.S.S. Stainless Steel" is title of comprehensive data book dealing with the characteristics, fabrication and application of this versatile group of materials. Designing with stainless is important section of this book. Typical properties of austenitic, martensitic and ferritic stainless steel are tabulated, as are corrosion resistance data on various reagents. 82 pages. United States Steel Corp.

Circle 559 on page 19

Weldments & Bases

Typical welded bases for machines and equipment produced by this company, as well as production facilities which include shearing, punching, bending, machining, welding, cutting, assembling and finishing are detailed in illustrated bulletin. 8 pages. Littleford Bros., Inc.

Circle 560 on page 19

Industrial Engine

Complete specifications on the 354 cu in. displacement, model 56A, V-8, industrial gasoline engine are presented in bulletin. Engine is available also in open and enclosed skid-base mounted power units. 4 pages. Chrysler Corp., Marine & Industrial Engine Div.

Circle 561 on page 19

Drafting Machine Scales

Aluminum, plastic and wood scales for Universal drafting machines are readily selected by means of a "Scale Selector" which describes available types and graduation styles. 6 pages. Universal Drafting Machine Corp.

Circle 562 on page 19

Steel Hydraulic Tubing

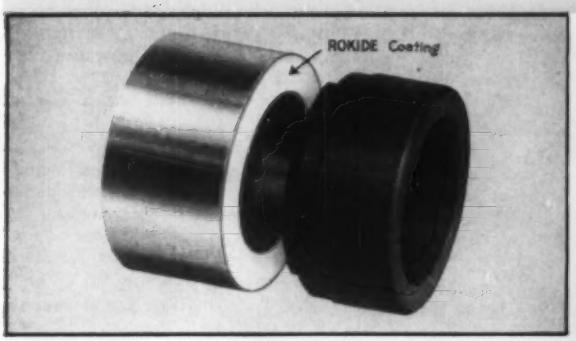
Features of Hydraluster bright finish steel tubing which adapt it for hydraulic service are detailed in illustrated bulletin HY-56. Sizes range from ⅛ to 1-in. OD with working pressures ranging from 8400 to 1900 psi, respectively. 4 pages. Summerill Tubing Co.

Circle 563 on page 19

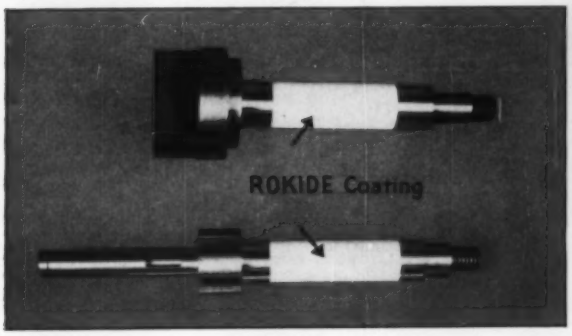
Liquid Pumps

Light weight, compactness, smooth flow without pulsation and easy maintenance are advantages reported for Moyno progressing-cavity fluid pumps. Seven sizes are detailed in bulletin 30-C for pressures to 600 psi, while 5 to 20 gph fuel oil pumps with discharge pressures to 100 psi

ROKIDE* Spray Coatings Add Life to Many Different Parts



In the upper photo courtesy of the Durametallic Corporation, the arrow shows where ROKIDE coating is applied to Dura Seals developed by this organization for sealing many chemicals. On the ring at left, the ROKIDE coating provides ideal mating with the carbon gland insert at right. This assures a tight, long wearing seal. In the photo below, ROKIDE coatings, indicated by arrows, provide equally valuable wear resistance for parts such as metal shafts.



ROKIDE coatings can be applied to parts of a wide variety of shapes and sizes. These new coatings are produced by heating the end of a solid rod and projecting the molten particles at a high velocity against a prepared surface where they adhere and solidify. Already in use for many military and commercial applications, ROKIDE coatings are also being tested on many other jobs.

Norton ROKIDE spray coatings are hard, adherent crystalline refractory oxides. They protect a variety of underlying materials, particularly metals, with benefits including:

Great resistance to wear, thermal shock and corrosion . . . low friction surface . . . high melting point . . . excellent mechanical strength . . . dimensional stability . . . relative chemical inertness . . . perfect mating for carbons.

The Three Types

ROKIDE "A" aluminum oxide, ROKIDE "ZS" zirconium silicate and ROKIDE "Z" zirconium oxide have proved successful for many uses. For example, in applications involving electrical insulation, electronics, bearing surfaces, erosion protection, corrosion resistance, chemical barriers, material upgrading, surface catalyst activity, general wear resistance and altering emissivity and characteristics of surfaces.

Facilities for applying ROKIDE coatings are maintained at Norton Company, Worcester, Mass., and at its plant 2555 Lafayette Street, Santa Clara, Cal. For the latest ROKIDE Bulletin, write to NORTON COMPANY, 765 New Bond St., Worcester, Mass.

NORTON
NEW PRODUCTS
Making better products... to make your products better
NORTON PRODUCTS:
Abrasives • Grinding Wheels
Grinding Machines • Refractories
BEHR-MANNING DIVISION:
Coated Abrasives • Sharpening Stones • Behr-cat Tapes
*Trade-Mark Reg. U. S. Pat. Off. and Foreign Countries

Circle 460 on page 19

are covered in bulletin 50. 8 and 4 pages. Robbins & Myers, Inc., Pump Div.

Circle 564 on page 19

Bevel Gears

Technical data and line drawings are used to explain the features of the Zerol bevel gear system in accordance with the 1956 revision. Tables and formulas supplement the text. 12 pages. Gleason Works.

Circle 565 on page 19

Thread-Cutting Fasteners

Springtite and Sem thread-cutting and self-tapping screws for sheet metal and steel parts assembly, for die castings and light metals, and for plastics are listed in illustrated bulletin S-49A. Eaton Mfg. Co., Reliance Div.

Circle 566 on page 19

High Strength Steels

Recently added M grade high strength steel also offers resistance to abrasion and fatigue. Properties and application data are given in bulletin ADV. 773. 4 pages. Republic Steel Corp.

Circle 567 on page 19

General Purpose Relays

Alternating and direct current relays for electronic, refrigeration, industrial, appliance, communication and automotive industry applications are detailed in bulletin 1060. Design and performance data are tabulated. 8 pages. Essex Wire Corp., RBM Div.

Circle 568 on page 19

Multiple Feed Oilers

Tapered feed adjusting screws in improved line of multiple feed oilers assure accurate control of lubrication in wide range of equipment. Full details and installation suggestions are given in bulletin 33-A. 4 pages. Trico Fuse Mfg. Co.

Circle 569 on page 19

Custom Fabrication

Company facilities for working all types of metals in fabrication of custom parts and equipment are subject of brochure "Let Tornqvist Do It." Prototypes or one-of-a-kind products are specialties of this company. 12 pages. Tornqvist Co.

Circle 570 on page 19

Lubrication Fittings

Hydraulic leakproof, flush type, ball-in-head, and giant and standard button head grease fittings for proper lubrication of machinery are described in bulletin "Precision Engineered." Dimensioned drawings give design aid. 8 pages. Universal Lubricating Systems, Inc.

Circle 571 on page 19

Strip Chart Recorders

Identicharts record on strip charts from remote point the exact time or sequence conditions occurring in process control and test work. Described in folder, the instruments make possible accurate chart interpreting after recording. 4 pages. Royson Engineering Co.

Circle 572 on page 19

Adhesives, Coatings, Sealers

Method of application and properties of eight typical Ray-Bond adhesives, coatings and sealers are summarized and tabulated in bulletin 650A. Adhesives are of both thermosetting and thermoplastic types. A graph shows shear strength of five types. 4 pages. Raybestos-Manhattan, Inc.

Circle 573 on page 19

Polyethylene for Extrusion

Dylan polyethylenes 3000 and 3016, formulated for polyethylene pipe extrusion, are described as to characteristics and properties in technical bulletin C-5-224. Extrusion process is also highlighted along with pipe applications and installation. 16 pages. Koppers Co., Chemical Div.

Circle 574 on page 19

Remote Control

Improved model of the Hydra Trol remote control has positive stroke in both directions for immediate synchronization of hydraulics control system in either direction. Available bulletin describes this control and details many of its uses. Trimont Instrument Co.

Circle 575 on page 19

Metal Deposition Process

"Electrolizing" is title of booklet describing this process for depositing a hard, dense, nonmagnetic alloy on the surface of a basis metal to give it surface hardness, low coefficient of friction and antiseizing properties. Dimensional tolerances can be held within $\pm$ 0.000025-in. 24 pages. Electrolizing Corp.

Circle 576 on page 19

Industrial Design

Recent brochures prepared by company which specializes in research and development for industry and the military include three bulletins covering "Electronics and Instrumentation," "Mechanical and Fluid Systems Engineering" and "Automation Engineering." 6 pages each. Designers for Industry.

Circle 577 on page 19

Servo System Analyzer

Five Servoscope servo analyzers described in bulletin TDS 1100 include the new model F developed to measure frequencies as high as 100 cps, yet afford low end coverage at 0.005-cps. How-to-use instructions are given. 4 pages. Servo Corp. of America.

Circle 578 on page 19

Vibration Test Systems

Six vibration test systems which feature the model 174 wide-band shaker are briefly described as to system performance in folder 17400. Systems have up to 1500 lb force output. 6 pages. Calidyne Co.

Circle 579 on page 19

Quality Forgings

Tabbed brochure J-6656 on forgings produced in three plants emphasizes specialization, engineering, research, versatility, ingenuity, control and economy aspects of this company's efforts. Company facilities are well illustrated. 16 pages. American Brake Shoe Co., AmForge Div.

Circle 580 on page 19

Pump Valves

Redesigned pump valves incorporate a new taper-lock stud, self-locking nut and drop-on guard. Features of the new design are described and illustrated in bulletin 400, along with pressure-temperature ratings, dimensions and other data. 8 pages. Durabla Mfg. Co.

Circle 581 on page 19

Wheels

"Allied Reference List and Engineering Data Catalogue" facilitates selection of correct wheels for specific applications. Data covers light industrial, drive and heavy industrial wheels with rated loads from 30 to 350 lb. 24 pages. Allied Wheel Products, Inc.

Circle 582 on page 19

Potentiometer Data

"Measurement and Correction of Phase Shift in Copper-Mandrel Precision Potentiometer" is latest technical paper 552. Discussion covers quadrature voltage and phase shift in potentiometers used in ac circuits. Text is supported by schematics, ta-

The PUSH behind the Sidewinder's Sting!

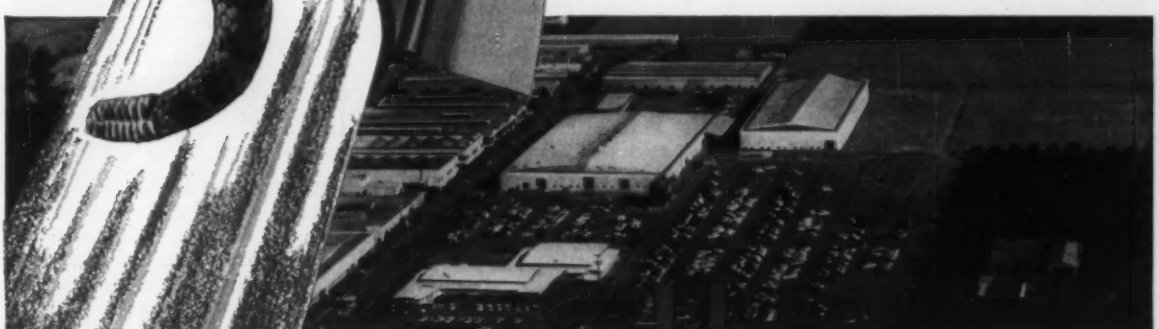
...A development of Hunter Douglas

Effective at altitudes up to 50,000 feet, the Navy's air-to-air guided missile, SIDEWINDER, is a rugged, sensitive and reliable weapon. Encompassed in its incredibly small 5" diameter and 9'5" length are all necessary propulsion and guiding equipment plus a deadly warhead. Surprisingly, the SIDEWINDER is unusually economical; produced at a cost comparable to a load of aircraft cannon bullets... *an economy resulting directly from Hunter Douglas technical achievements in the field of cold forging!*

The major problems of producing a light, strong motor tube meeting precision tolerances required in this type of propulsion unit were solved by Hunter Douglas. The SIDEWINDER motor tube was produced as a single precision aluminum cold forging integrating the tube and wing supporting channel ring section, eliminating costly assembly operations and alignment difficulties. The tube is typically straight within .020" TIR, I. D. within .006", wall thickness within .0015" and yield strength of 72,000 psi minimum.

Completion of Hunter Douglas experimental cold forging techniques helped pave the way for mass production of the SIDEWINDER. Today, Hunter Douglas is the only successful producer of this complex cold forged component and is the prime contractor to the U. S. Navy, delivering the completely assembled SIDEWINDER motor, ready for final addition of propellant, warhead and guidance unit.

Behind this notable Hunter Douglas achievement stands a strong integrated business structure combining technical resources, manufacturing facilities and the coördinated staff to see all jobs "WELL DONE."



Hunter Douglas Aluminum

Division of
BRIDGEPORT BRASS COMPANY
Dept. MD-6, Riverside, California, Telephone OVerland 3-3030

bles, graphs and equations. 30 pages. Helipot Corp.

Circle 583 on page 19

Special Stainless Steels

Technical data including physical and mechanical properties, resistance to corrosion and oxidation are included in Blue Technical Data Sheet on "Allegheny Stainless Steel Type 418 Special." It has 750-1100° F use range. 4 pages. Allegheny Ludlum Steel Corp.

Circle 584 on page 19

Rotary Switches

High speed rotary switches for telemetering, sampling and programming are described and illustrated in folder. Specifications, physical features, and performance data are included. 4 pages. Instrument Development Laboratories, Inc.

Circle 585 on page 19

Fractional HP Drives

Detailed in illustrated catalog V-147-J are cast iron, bar and pressed steel and die cast sheaves, die cast couplings and belts for fractional horsepower drives. Dimensional data and diagrams are included. 24 pages. Browning Mfg. Co.

Circle 586 on page 19

Lead-Treated Steels

Freer machining, faster feeds and speeds, longer tool life and better finish are advantages reported from use of lead treated steel. Properties of leaded steels versus nonleaded types are tabulated in brochure. Grades currently produced are listed. 8 pages. Copperweld Steel Co.

Circle 587 on page 19

Hose Clamps

Variety of hose clamps for automotive, industrial and other applications is shown in catalog A-457. Dimensional data for all models are included. 4 pages. Wittek Mfg. Co.

Circle 588 on page 19

Vibrationproof Nuts

"Fastest Thing in Fastenings" is title of catalog 333 which illustrates wide variety of Speed Nuts. Principle of spring tension fastening and details of several basic types are covered, along with several applications. Specifications are given. 12 pages. Tinnerman Products, Inc.

Circle 589 on page 19

Chrome-Nickel Alloy

Thermalloy 30 chrome-nickel alloy is suitable for heat-treatment service in 1200 to 1600°F range, in automotive, farm equipment and petroleum refining industries. General characteristics, tensile and other properties and applications are covered in bulletin T-211. 4 pages. American Brake Shoe Co., Electro-Alloys Div.

Circle 590 on page 19

Metal Treatment

Rust prevention, mechanical and chemical cleaning, blackening, phosphating and other types of surface treatment of metals are covered in descriptive booklet. Various treatment processes are diagrammed or illustrated photographically. Company surface treatment products are listed. 84 pages. E. F. Houghton & Co.

Circle 591 on page 19

Production Facilities

Illustrated folder "You Mean Chicago Can Handle the Complete Job?" relates how this company can serve as an extension of your own engineering and production facilities. Services it renders and typical products produced are covered. 4 pages. Chicago Screw Co.

Circle 592 on page 19

Nozzles

Extensive series of nozzles, including center jet, impactor, free flow, tangential, ramp bottom, flat, mist spray, pinjet, internal mix and atomizing types, is covered in illustrated spiral-bound catalog. Specifications of all units are given, along with self-cleaning strainer data. 30 pages. Spray Engineering Co.

Circle 593 on page 19

Coupling

Quick-connect, quick-disconnect HK coupling for acid, alkali, solvent and high pressure steam lines is described on illustrated data sheet. Using Teflon seals, it has a −100 to 500° F range. 2 pages. Snap-Tite, Inc.

Circle 594 on page 19

Bearing Bronze

What Promet bronze is; its availability in bushings, bearings, bar stock, and babbitt metal; and its properties are covered in illustrated brochure. Application case histories are included. 8 pages. American Crucible Products Co.

Circle 595 on page 19

Fractional HP Motors

Rigid mounting split-phase and resilient mounting capacitor-start fractional horsepower motors for appliances and small tools are described in illustrated bulletin 2801. Ratings are 1/8 to 1/3 hp. Design features and specifications are given. 4 pages. Westinghouse Electric Corp.

Circle 596 on page 19

Aluminum Tube

Low cost, easy workability and high fatigue strength are features of Utilitube aluminum coiled tube brought out in illustrated brochure AD-270. Its advantages, applications, installation and technical data are covered. Ten diameters from 1/4 to 3/4-in. have bursting strengths from 7380 to 2550 psi, respectively. 8 pages. Aluminum Co. of America.

Circle 597 on page 19

Malfunction Detector

Rotating and reciprocating machinery are protected by the Vibraswitch malfunction detector, subject of illustrated bulletin 600-1. It shuts down the equipment or sounds an alarm. Various models described protect pumps, motors, compressors, generating equipment, fans and blowers. 4 pages. Robertshaw-Fulton Controls Co., Fielden Instrument Div.

Circle 598 on page 19

Pumps

Chart which aids users of fluid-handling equipment in choosing the pump model best suited for their needs is contained in data folder 343. It gives heads, capacities and other data on pumps for wide variety of jobs. Various drives are available. 4 pages. Barnes Mfg. Co.

Circle 599 on page 19

Precision Optics

Engineering and production facilities for precision optics are detailed in illustrated bulletin 0-104. Flat, cylindrical, prismatic, spherical and aspherical components for instruments are made. Infrared silicon optics for use in hypersensitive infrared systems are subject of bulletin 0-105. 6 and 2 pages. Texas Instruments Inc.

Circle 600 on page 19

Compressors & Pumps

Line of Oil-Less air compressors and vacuum pumps with graphite piston rings and skirts is subject of illustrated bulletin GO-1156. Designed for portable or built-in use, compressors are made in capacities to 6.57 cfm for pressures of 35, 75 and 175 psi. Vacuum pump displacements are from 2.7 to 6.57 cfm. Specifications and application data are included. 12 pages. Bell & Gossett Co.

Circle 601 on page 19

Why COST CONSCIOUS men are choosing Norgren MICRO·FOG

1. Better Lubrication — Less Machine Down Time

MICRO-FOG lubrication automatically coats all the bearings, gears, chains and other components of a machine with a continuous, protective film of clean oil. Just the right amount of oil is applied to provide the most efficient lubrication, reducing wear on machine components and cutting maintenance and replacements costs.

2. Oil Always Fresh, Always Clean

There is no recirculation of deteriorated or contaminated lubricant to cause wear or corrosion. Clean oil is applied continuously to all lubrication points in carefully metered amounts.

3. For Large and Small, Plain and Anti-Friction Bearings

MICRO-FOG Lubricating systems have found enthusiastic acceptance for use on all types of machinery, ranging from *high* speed grinders to huge roll mill bearings on shafts as large as 34" in diameter and turning at relatively *low* speeds.

4. Centralized, Automatic Lubrication

A single, MICRO-FOG Lubricator will automatically deliver enough airborne lubricant, proportionately distributed to completely lubricate even a large machine tool. Only one lubricator to maintain and refill.

5. Big Savings in Lubricant

Carefully metered quantities of oil are applied to each lubrication point. MICRO-FOG provides more thorough lubrication using only a few ounces of oil per day than other methods using several gallons of oil per day.

6. Bearings Run Cooler

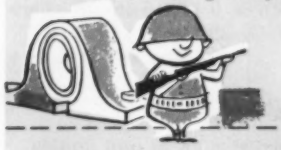
Air passing through the bearing carries away heat, and there is no pool of lubricant in the bearing to generate heat as a result of fluid friction. Lubrication is continuous — there are no periods of insufficient lubrication with metal wearing on metal.

For Lubricating

- BEARINGS
- GEARS
- CHAINS
- SLIDES
- WAYS
- OTHER MACHINE COMPONENTS

7. Contaminants Excluded From Bearings

A slight positive pressure is maintained within the bearing, and air continuously escapes from the bearing, preventing the entrance of contaminants from the surrounding atmosphere.



8. Fewer Bearing Seals Required

Because MICRO-FOG must be vented to the atmosphere, it is not necessary to maintain tight seals. Fewer oil seals are required, reducing maintenance and machine down-time.

9. Oil Filters, Sumps and Pumps Eliminated

The quantity of lubricant used in MICRO-FOG Lubrication System is so small that there is nothing to reclaim or recirculate. Expensive high pressure piping is also eliminated.

10. Automatic Alarm Controls

MICRO-FOG Lubricators are available with switches to actuate an alarm system or controls as a warning of conditions affecting proper lubrication.

11. Visible Oil Feed

The oil feed is readily visible on all models of MICRO-FOG Lubricators, providing positive proof that the lubricator is operating properly.

12. A MICRO-FOG Lubricator For Every Size Machine

19 models to choose from—ratings up to 1,000 bearing inches and oil reservoir capacities up to 4½ gallons.

For complete information, call your nearby Norgren Representative, or WRITE FOR NEW 800 CATALOG.

C. A. NORGREN CO.

3442 SO. ELATI ST., ENGLEWOOD, COLORADO

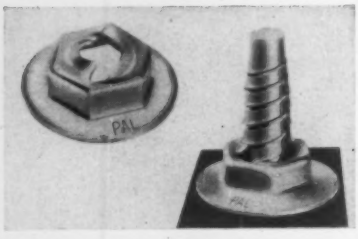
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Locknut

cuts its own threads

Self-threading locknut cuts its own threads on die-cast or cold-forged studs of nameplates, medallions, emblems and moldings. Made of spring-tempered steel, unit comprises a thread-cutting locknut and flat washer in one piece, in sizes for ⅛, 3/16 and ¼-in. unthreaded studs. Nut is hex form to fit standard tools and shanks. It cuts deep, clean threads having



high torque and tensile values, and can be removed and reused on same studs. Resilient washer base assures full 360-deg contact on flat or irregular work surfaces, and on perpendicular or off-angle studs. Unit is available plain or with bonded-in plastisol sealer for assemblies requiring protection against water and dust. **Palnut Co.,** Glen Rd., Mountainside, N.J.

Circle 602 on page 19

Miniature Limit Stop

for incorporation in servo systems

Miniature mechanical limit stop, contained in a size 11 synchro housing, is suitable for direct incorporation into production servo systems without special mounting hardware. Unit is lead-screw type, permitting total travel of 40 revolutions. It can be continuously set over full range without remov-

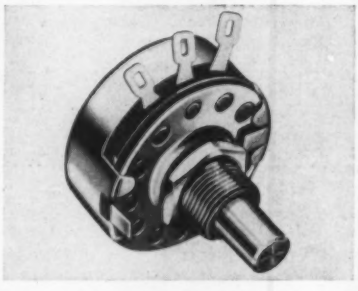
al from mechanical system. Leaf-spring stops protect delicate components and gears from jarring halts. Unit meets all applicable military environmental and vibrational specifications. **Reeves Instrument Corp.,** 207 E. 91st St., New York 28, N.Y.

Circle 603 on page 19

Adjustable Resistor

withstands temperatures to 150 C

Type K hot-molded composition adjustable resistor has excellent power dissipation. It is conservatively rated at 2 w under 100-C ambient operating conditions, and provides reliable performance at 150 C under no-load conditions. Resistor element, terminals, insu-



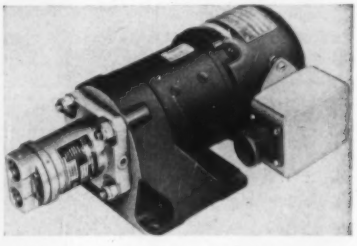
lation, faceplate, and threaded bushing are all hot-molded in a one-piece plastic body. Unit resists heat, cold, moisture and aging after molding, and has low noise characteristics. Resistor is furnished in single, dual and triple units, with plain or lock bushings. Shafts are plain, flatted or slotted in increments of ⅛-in. to 6 in. max. **Allen-Bradley Co.,** 136 W. Greenfield Ave., Milwaukee 4, Wis.

Circle 604 on page 19

Miniature Motorpumps

for missile applications

Miniaturized motorpumps have high pump efficiency and low starting torque, permitting use of a smaller, lighter electric motor. Pump has low current drain, and ability to operate at high speeds permits direct drive, thus saving space and weight. Model AA-19054, shown, delivers 0.84 gpm at 7400 rpm and 1000 psi. Hydraulic



pump weighs 1.0 lb and electric motor 7.0 lb. Overall length of both units is 9 15/16 in. **Vickers Inc.,** Detroit 32, Mich.

Circle 605 on page 19

Solenoid Valves

for corrosive gases and liquids

Type GX solenoid valves have only 316 stainless steel and Teflon in contact with flowing medium. Packless, they are for corrosive gases and liquids in ⅛, ¼, ⅜-in. pipe sizes with seven port sizes from 1/16 to ¼-in. Valves are normally closed, angle-pattern type. Greenclad, waterproof molded coils are used for temperatures to 250 F and silicone-insulated coils

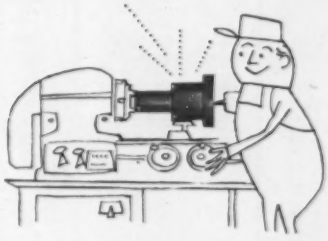
Q

Saving all you can on

Production Bronze Castings?

Here?

Here?



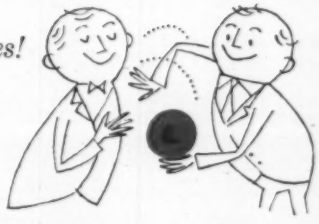
A

You do, with

Ampco Shell Moldings!

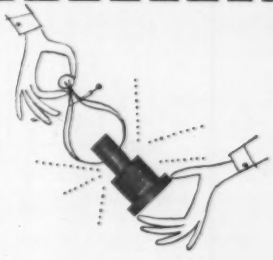
Smoother cast surfaces!

Often, smooth enough to use as is.



Closer tolerances!

Most castings held to ±.015 — favorable shapes, ±.010.

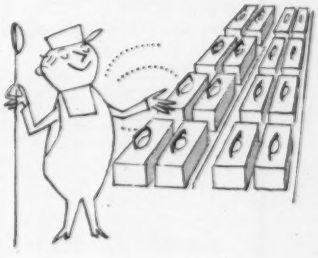


Less machining!

In some cases, finishing operations are eliminated.

Lower cost!

High-speed, semi-automatic mold production means foundry economy.



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AMPCO METAL, INC.
Milwaukee 46, Wisconsin

West Coast Plant:
Burbank, California

One-source service from raw material to finished product

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AMPCO METAL, INC.
Dept. MD-6, Milwaukee 46, Wisconsin

Send me Bulletin G-36 on shell moldings; also information on other Ampco products I have checked.

Name_____

Title_____

Company_____

Address_____

City_____ Zone____ State_____

- ☐ Specifications of Ampco Metal
- ☐ Ampco Wrought Products
- ☐ Ampco Stock Raw Materials
- ☐ Ampco in the Process Industry
- ☐ Ampco Centrifugal Pumps
- ☐ Ampco-Weld Resistance Welding Electrodes

D-61

YOUR CYLINDER ORDER SHIPPED IN 24 HOURS OR LESS!

LET CARTER CARRY YOUR INVENTORY!

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ANY STROKE

AIR OR HYDRAULIC

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Get your cylinders *now*, when you need them. No need to lose production because of poor delivery! Carter will *ship your cylinder order in 24 hours or less*, to satisfy your needs. And when you buy Carter cylinders, you buy quality—rugged, dependable cylinders.

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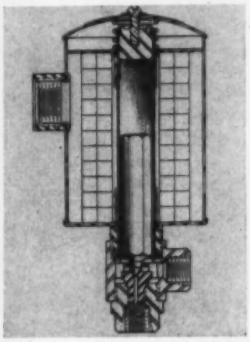
ROTARY ACTUATORS • SPECIAL CONTROLS

New Parts



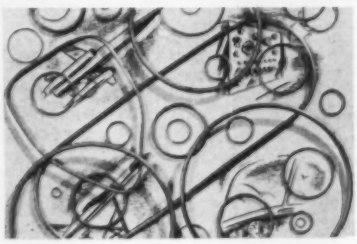
for higher temperatures. Explosionproof housings are available. **J. D. Gould Co.**, 4707 Massachusetts Ave., Indianapolis 18, Ind.

Circle 606 on page 19

Metal O-Rings

for high-temperature service

Rings of thin-walled tubing provide tight, long-lasting metallic seal with low flange load. They are suitable for applications involving high temperatures, acid and other corrosive conditions, radioactive and electronic conditions. They do not deteriorate in contact with most chemicals, oils or greases, and retain flexibility and resilience indefinitely when stored. Type 321 stainless steel is used



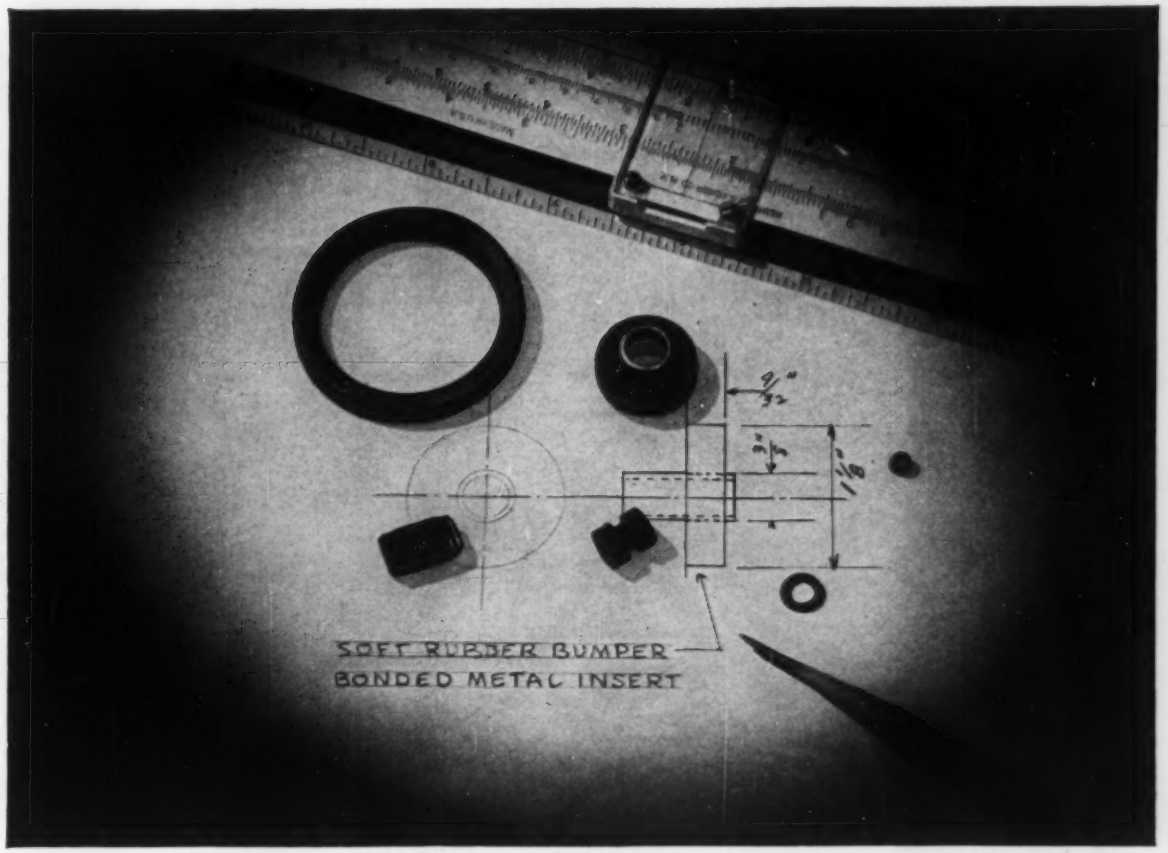
most frequently; stainless types 304, 316 and 347, Monel, Inconel and Inconel X are also used. Tubing diameters range from 0.125 to 0.035-in. **Advanced Products Co.**, P.O. Box 75, North Haven, Conn.

Circle 607 on page 19

Squib-Actuated Switch

for aircraft, missile and weapons components

Squib-actuated switch provides four sets of contacts furnished in any combination of normally open and normally closed positions.



Super soft rubber answers many problems!

SEALS! CUSHIONS! ABSORBS SOUND!

Here's an exciting new material formulated and developed by ROTH Rubber... a non-porous rubber with a softness from 5 Durometer up. Applications range all the way from a tiny, sound absorbing mounting ring used in a hearing aid to bonded conveyer belts where superior gripping and cushioning qualities are required. It may be the solution to *your* problem. Check the specifications, send the coupon for a free sample... ROTH will be happy to work with you.

PHYSICAL PROPERTIES—ROTH RUBBER COMPOUND D992

PROPERTY	UNAGED	AGED 70 HOURS						
		212F Air	212F #1 Oil	212F #3 Oil	200F Water	85F Isooctane	85F Type III Fuel	85F Naphtha
Hardness	7	27	30	1	8	9	5	9
Tensile Strength	500 psi	750	600	250	200	450	400	500
Elongation	800%	550	550	750	550	750	750	800
Compression Set	50%							
Volume Change	•	•	−36%	+90%	+25%	−17%	+20%	−2%
Cold Bend	−60F OK −65F Brittle							

Dielectric Strength measured on 4/5-inch thick slab: At 10,000 volts the rubber passes 2 micro-amperes of current; at 15,000 volts the insulation breaks down. High Temperature Use—estimated limit 200F.

ROTH MOLDS AND COMPOUNDS RUBBER TO MEET ALL SPECIFICATIONS. TELL US YOUR PROBLEM. NO OBLIGATION!

ROTH

RUBBER COMPANY

1860 S. 54th Avenue, Chicago 50

Send for free sample OF THE RUBBER THAT FEELS LIKE SKIN!

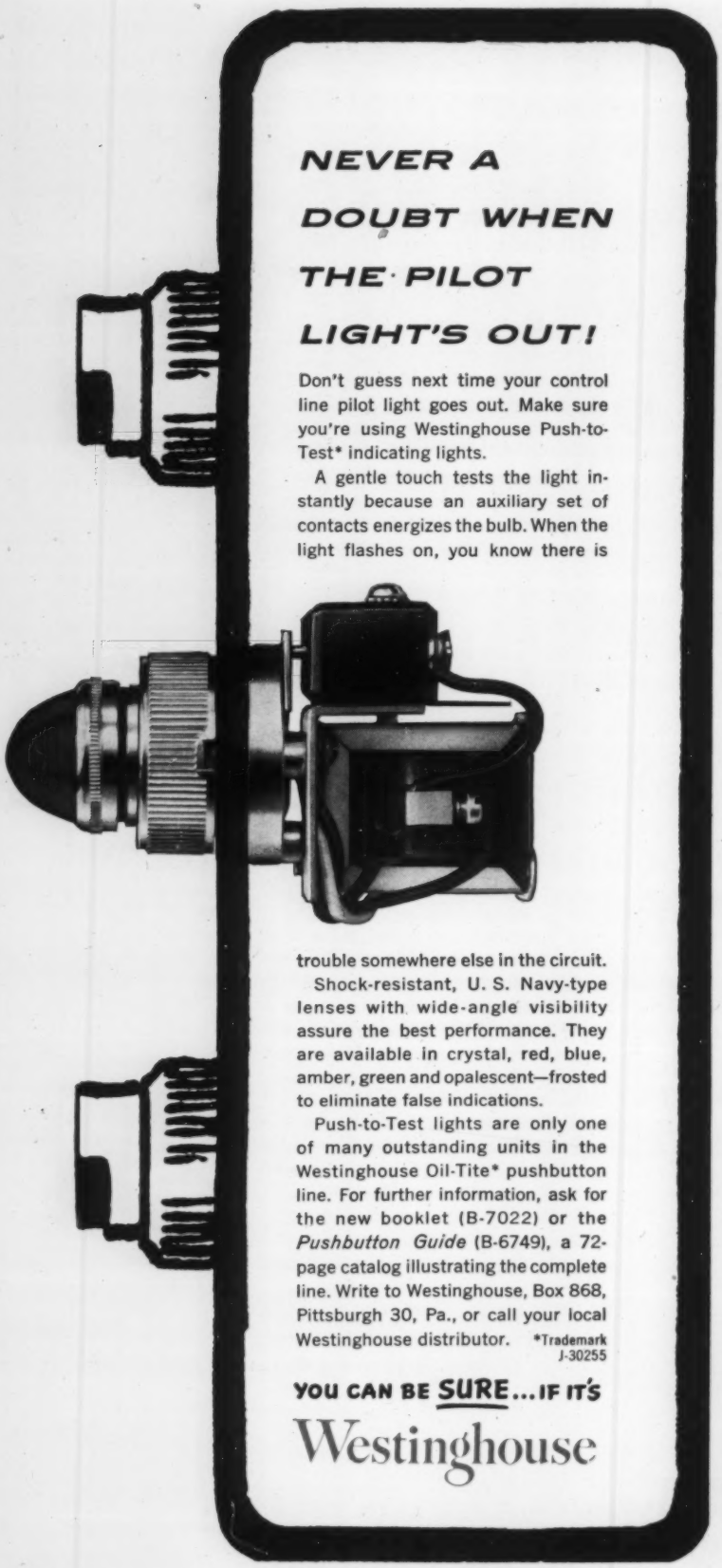
Name_____ Title_____

Company_____

Address_____

City_____ State_____

Circle 465 on page 19



NEVER A DOUBT WHEN THE PILOT LIGHT'S OUT!

Don't guess next time your control line pilot light goes out. Make sure you're using Westinghouse Push-to-Test* indicating lights.

A gentle touch tests the light instantly because an auxiliary set of contacts energizes the bulb. When the light flashes on, you know there is trouble somewhere else in the circuit.

Shock-resistant, U. S. Navy-type lenses with wide-angle visibility assure the best performance. They are available in crystal, red, blue, amber, green and opalescent—frosted to eliminate false indications.

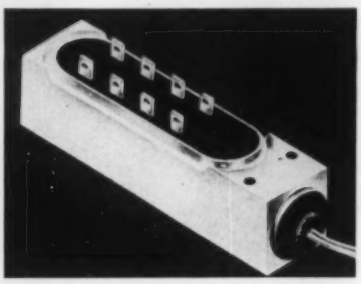
Push-to-Test lights are only one of many outstanding units in the Westinghouse Oil-Tite* pushbutton line. For further information, ask for the new booklet (B-7022) or the *Pushbutton Guide* (B-6749), a 72-page catalog illustrating the complete line. Write to Westinghouse, Box 868, Pittsburgh 30, Pa., or call your local Westinghouse distributor. *Trademark J-30255

YOU CAN BE SURE...IF IT'S

Westinghouse

New Parts

Switch is unaffected by vibration of 100 *g* amplitude from 20 to 2000 cps, and is not damaged by shock acceleration of 15,000 *g* in any direction. Unit is designed for use in aircraft, missile and special



weapons components. Encased in a metal housing, ½ x ½ x 2 5/32 in., unit is sealed to permit potting in wax or resin compounds. **Atlas Powder Co.,** Parke Thompson Ordnance Section, 9404 Watson Rd., St. Louis 19, Mo.

Circle 608 on page 19

Plastic Sheet

is extremely flexible

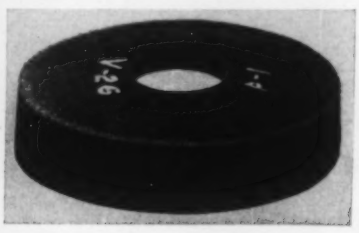
Grade EEF flexible reinforced plastic sheet is used as an insulating material in electrical and electronic applications. It is 1/32-in. thick. Applications include use as transformer layer insulation. **Hays Mfg. Co.,** Reinforced Plastics Div., 801 W. 12th St., Erie, Pa.

Circle 609 on page 19

Cups and Packings

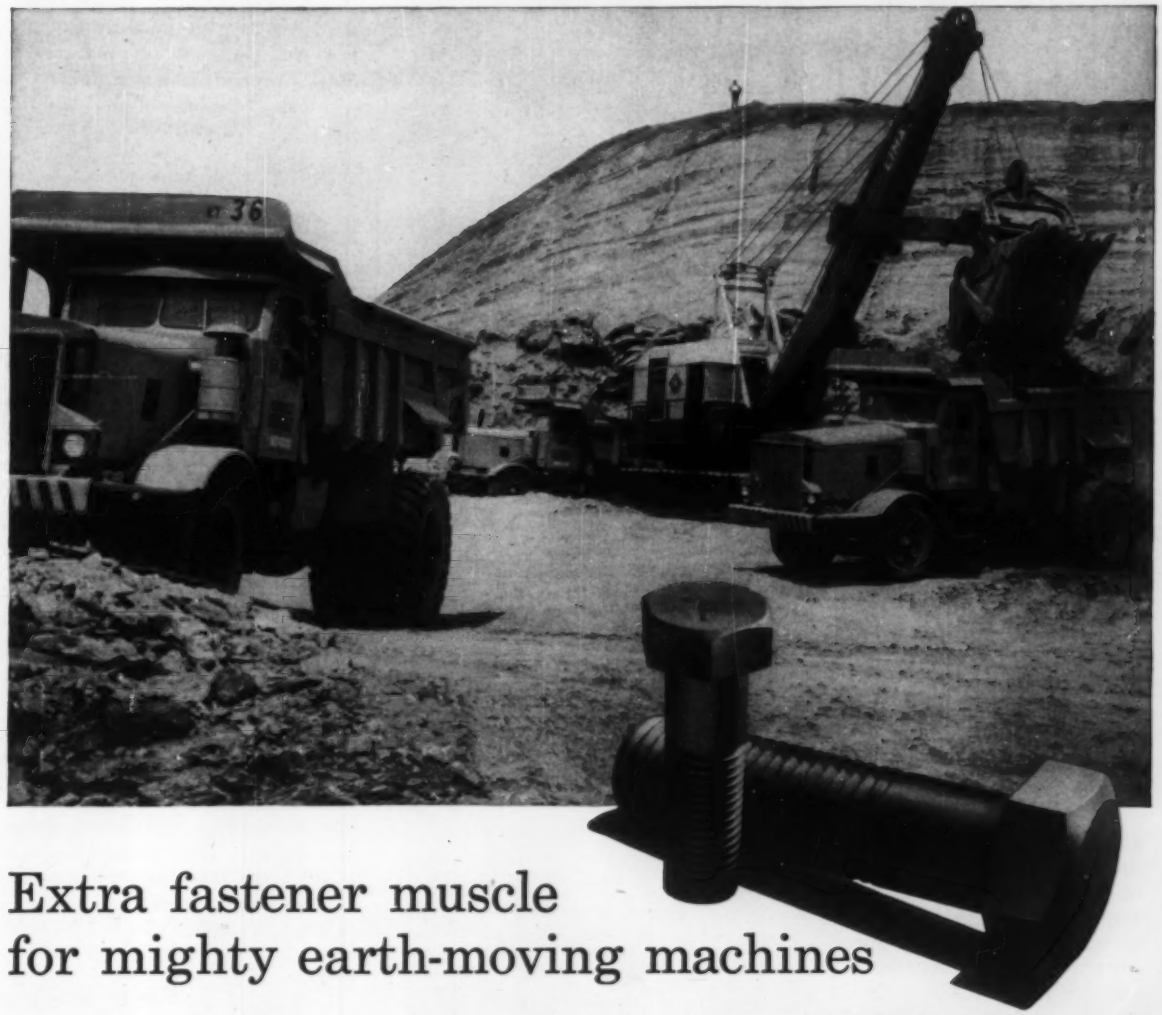
are preformed to shape

Cups and packings of elastomer impregnated mechanical leather are preformed on special dies to produce a sharp, rather than round heel. Preforming provides greater density at heel of cup and eliminates operational stress and flexing. Cups have been used in heavy-duty applications, such as farm and



Circle 466 on page 19

CLEVELAND STANDARD HEXAGON HEAD CAP SCREWS



Extra fastener muscle for mighty earth-moving machines

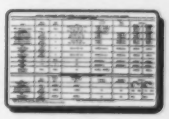
Power shovels, trucks, bulldozers—all take brutal shock loads and vibration, day in, day out. To reduce repairs and downtime to a minimum, leading manufacturers of earth-moving equipment specify Cleveland cap screws with confidence. These upset forged hexagon head cap screws put extra strength into every assembly, insure customer satisfaction.

Cleveland standard hexagon heads are manufactured from various steels and in various tensile strengths. Included are extra-large diameters and long lengths. Bright and quenched and tempered steels in all standard sizes are ready for immediate delivery—alloy steels on short notice. Let our experienced engineers help you with your fastener problems. Remember, Cleveland has the most modern of production facilities and the world's largest stock of hexagon head cap screws.

TENSILE STRENGTHS OF CLEVELAND HEXAGON HEAD CAP SCREWS

Product	Size, in.	Tensile Strength, psi
Bright	Up to 7/8 incl. 1/2 to 1 1/8 incl. Over 1 1/8 to 1 1/2 incl.	85,000—105,000 75,000—100,000 65,000 min.
Quenched & Tempered (SAE Grade 5)	Up to 3/4 incl. Over 3/4 to 1 incl. Over 1 to 1 1/2 incl.	120,000 min. 115,000 min. 105,000 min.
Quenched & Tempered (SAE Grade 6)	Up to 5/8 incl. Over 5/8 to 3/4 incl.	140,000 min. 133,000 min.
Alloy (SAE Grade 7)	Up to 1 1/2 incl.	130,000 min.
Alloy (SAE Grade 8)	Up to 1 1/2 incl.	150,000 min.
Bright	Over 1 1/2 to 2 1/2 incl.	55,000 min.
Quenched & Tempered	Over 1 1/2 to 2 1/2 incl.	90,000 min.
Alloy	Over 1 1/2 to 2 1/2 incl.	125,000 min.

Note: Higher physicals, through use of selected alloys, can be supplied on special order.



GET YOUR COPY NOW — Pocket-size card giving you physical properties of Cleveland hexagon and socket head cap screws and Cleveland Place bolts.

THE CLEVELAND CAP SCREW COMPANY
4444-6 Lee Road, Cleveland 28, Ohio
WAREHOUSES: Chicago • Philadelphia • New York • Los Angeles

Circle 467 on page 19

YOU insure

RUGGED FIELD PERFORMANCE

plus PRODUCTION SAVINGS

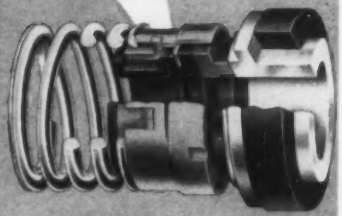
when you specify these

JOHN CRANE MECHANICAL SEALS

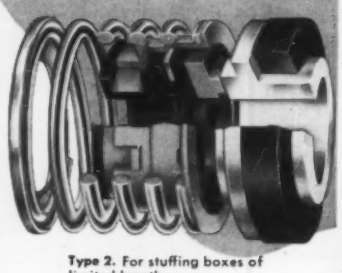
"JOHN CRANE" Types 1 and 2 shaft seals come pre-assembled. They are quickly and easily installed. Tolerances need not be critical due to the self-adjusting seal head. This is accomplished through special construction of the synthetic rubber bellows head. Moving freely under spring and hydraulic pressure, it automatically compensates for shaft end play, as well as washer wear.

Sealing faces are precision-lapped to prevent stuffing box leakage. No break-in runs necessary. Positive drive feature eliminates all stress on bellows. This feature also permits the use of light spring load to minimize wear on sealing faces. Seal needs no attention over long periods of operation.

Recommended for water, oil and other services non-injurious to synthetic rubber. Pressures to 200 psi. Temperatures: –40° to +212°F.



Type 1. For stuffing boxes of limited diameter.



Type 2. For stuffing boxes of limited length.

Above seals also available in balanced construction (1-B, 2-B) for pressures up to 500 psi.

Write for Bulletin S-213-1

Crane Packing Co., 6425 Oakton St., Morton Grove, Ill., (Chicago Suburb). In Canada: Crane Packing Co., Ltd., Hamilton, Ont.

JOHN CRANE CRANE PACKING COMPANY 38 YEARS INDUSTRIAL PROGRESS

New Parts

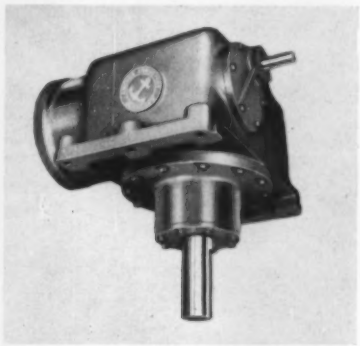
road-building equipment and steel-mill equipment at oil pressures to 3500 psi, and in air cylinders at 150 psi. **Chicago Rawhide Mfg. Co.**, 1301 Elston Ave., Chicago 22, Ill.

Circle 610 on page 19

Speed Reducer

for conveyor drives has changeable ratio

This reducer is designed primarily for conveyor-drive applications requiring a vertical output shaft. Design incorporates quick change of



total ratio with stock gears, without disturbing balance of drive, and dry well construction. Reducer is of heavy-duty construction and is available in standard sizes and ratios. **Anchor Steel & Conveyor Co.**, 6906 Kingsley, Dearborn, Mich.

Circle 611 on page 19

Transistorized Equipment

includes transformers, voltage regulators, inverters

Glennite transistorized dc transformers are completely static devices which replace vibrators and dynamotors. Available in voltages to 500 v dc, they have dc output voltage directly proportional to input. Characteristics include load regulation from 6 to 12 per cent, ripple of 0.01 per cent, output range from 15 to 80 w with input at 24 to 30 v dc. Dc voltage regulators consist of a transistorized oscillator employing magnetic amplifier as regulating element. Regulators feature small size, fast response, tantalum capacitors and low ripple. Transistorized dc inverters provide

Circle 468 on page 19

Lasting corrosion protection for valve stems in storage. Ordinary corrosion inhibitors fail to protect after the sacrificial metal is consumed. J-M No. 9 operates on an entirely different principle. Photograph shows how under accelerated tests, the sacrificial inhibitor (at left) failed after a few weeks *but the valve stem protected by J-M No. 9 (at right) was clean months later.* Specify J-M No. 9 inhibitor when you order J-M die-formed packing rings.

J-M Die-formed Packing Rings for all process fluids

Whether you are designing a bathroom fixture or a high-pressure valve, you can now choose your packing rings with greater certainty of both maximum sealability and easy assembly. For Johns-Manville has grouped its die-formed packing rings into three tolerance ranges—*dense*, *soft* and *metallic*—to fit your equipment needs.

Johns-Manville Die-Formed Packing Rings are precision-made for many fluid services including oils, tars, corrosives, solvents, fresh and salt water, steam to 1200 F, pressures to 3000 psi (on special valves to 60,000 psi). Special J-M rings with controlled friction are made for high-grade plumbing fixtures.

Check the tolerance chart below . . . your Johns-Manville Packing Representative will be glad to give you lists and descriptions of the styles in each range and those with which the J-M No. 9 Corrosion Inhibitor (*see right above*) may be specified or is standard. Write Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

JOHNS-MANVILLE DIE-FORMED PACKING RING TOLERANCES	DENSE RINGS (including plastics)			SOFT RINGS (including cloth rings)			METALLIC RINGS		
	I.D.	O.D.	Depth	I.D.	O.D.	Depth	I.D.	O.D.	Depth
to and incl. ½" O.D.	+.008" −.000"	+.000" −.008"	±1/64"	+.008" −.000"	+.000" −.015"	±1/64"	+.008" −.000"	+.000" −1/32"	±1/32"
Over ½" to and incl. 1" O.D.	+.008" −.000"	+.000" −.008"	±1/32"	+.008" −.000"	+.000" −.015"	±1/32"	" "	" "	" "
Over 1" to and incl. 2⅜" O.D.	+.008" −.000"	+.000" −1/64"	±1/32"	+.010" −.000"	+.000" −1/32"	±1/32"	" "	" "	" "
Over 2⅜" O.D.	+.010" −.000"	+.000" −1/32"	±1/32"	+.010" −.000"	+.000" −3/64"	±1/32"	" "	" "	" "

Bevel (on all styles) ±5° when required

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville PACKINGS, GASKETS and TEXTILES

Heavy-duty bearing
for strip-mine shovels
and drag lines;
finish-machined

YOU CAN'T BEAT **NBD** FOR
MACHINED **BRONZE** BEARINGS

For heavy-duty bronze castings, you can't beat NBD quality, casting know-how and machining facilities. Weights up to 20,000 lbs . . . machined to any degree of finish . . . in sizes up to 72 inches in diameter. Precise tolerances held to your specifications.

Many leading equipment manufacturers are taking advantage of our years of specialization in bronze metallurgy . . . our more than 40 special bronze alloys . . . our complete facilities for sand casting, shell mold, cast-to-size and centrifugal casting.

Want quotes or information? Just call or write.

AMERICAN Brake Shoe COMPANY

NATIONAL BEARING DIVISION
4930 Manchester Avenue • St. Louis 10, Missouri
PLANTS IN: CHICAGO • ST. LOUIS • MEADVILLE, PA.

New Parts

power for rate gyros where frequency regulation is necessary. Supplied with normal output of 115 v ac, characteristics include line wave of 400 cps and temperature range of −55 to 71 C. **Gulton Industries Inc.,** Engineered Magnetics Div., 212 Durham Ave., Metuchen, N.J.

Circle 612 on page 19

Machine Bases

are 3/16 to 5/16-in. thick steel plate

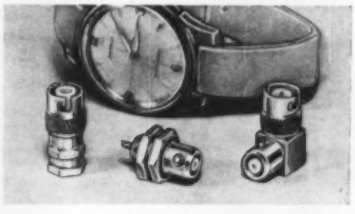
Standard machine bases are made of steel plate ranging from 3/16 to 5/16-in. thick. Any size base from 24 to 48 in. long or wide and from 24 to 54 in. high can be assembled quickly, parts being drilled for bolting together for welding. Bases have high salvage value since they can be reused by making changes in tooling. **Inter-Lakes Engineering Co.,** 39200 Groesbeck Highway, Mt. Clemens, Mich.

Circle 613 on page 19

Miniature Connectors

for RF coaxial cable

Twelve different groups of DM jacks, receptacles and adapters withstand a cable pull of over 50 lb. Twelve polarities prevent wrong connections. Bayonet locking meets MIL-C-5015 and provides vibrationproof coupling. Tef-



Circle 470 on page 19

lon insulators permit use over wide temperature range with low electric loss. Connectors are available for use with any miniature cable. **Dage Electric Co. Inc.**, 67 N. Second St., Beech Grove, Ind.

Circle 614 on page 19

Synthetic Sapphires

in large single crystals

Large single crystals of synthetic sapphire are available in many shapes, such as rods, disks, tubes, domes and balls. Disks have diameters up to 3 in. and thicknesses from 0.005 to ½-in. Rods with diameters from 0.010 to 0.290-in. are in lengths from 1½ to 18 in. Synthetic sapphire exhibits extreme hardness and resistance to acids

and alkalies at elevated temperatures. It is an excellent electrical insulator, shows strength at high heats, has a melting point of 2040 C. **Linde Co.**, Div. of Union Carbide Corp., Crystal Products Dept., 420 Lexington Ave., New York 17, N. Y.

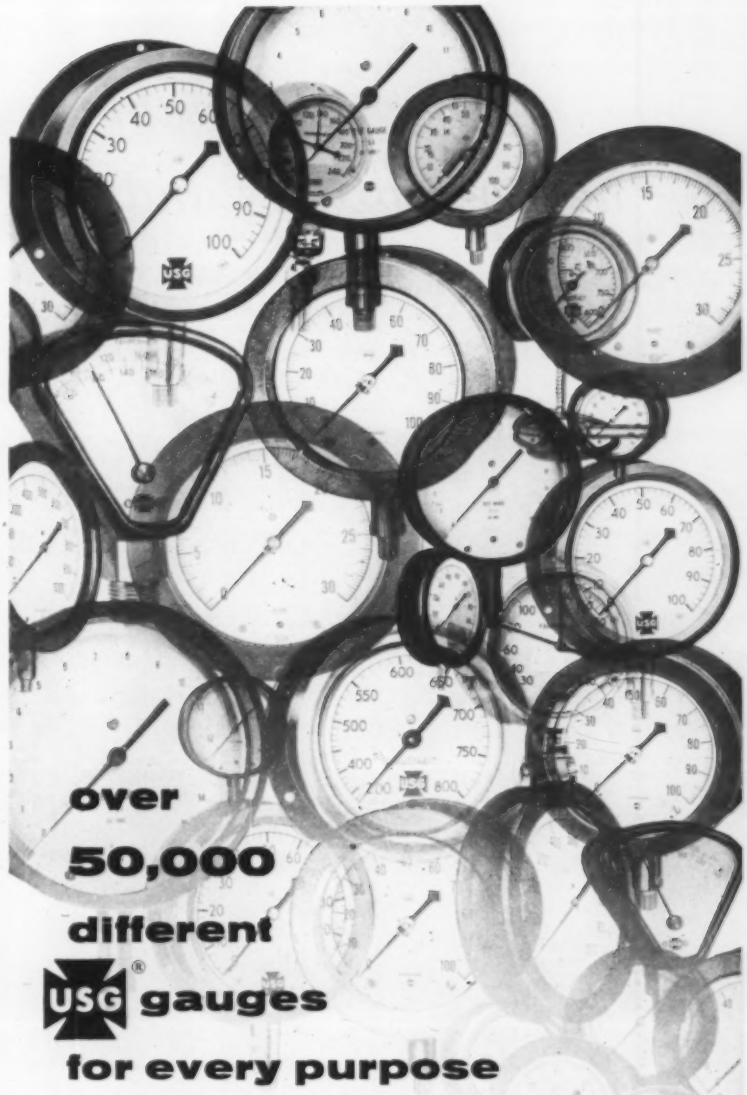
Circle 615 on page 19

Flexible Coupling

utilizes rubber tire to cushion shock loads

Para-flex flexible coupling handles angular misalignment, parallel misalignment and end-float, in any combination. Flexible member cushions shock loads and diminishes torsional vibration to protect driver and driven machine. Coupling incorporates a tire with synthetic tension members bonded together in rubber. Tire is clamped between two hubs mounted on shafts to be coupled. Transverse

(*Continued on Page* 136)



If your product designs call for pressure or temperature instruments, your best source is United States Gauge.

Immediately available to you are 50,000 different standard gauges. Often, with only a slight modification, many of these standard gauges meet special design requirements, resulting in big savings to equipment manufacturers.

For help in lowering your gauge costs, call or write the factory today. Our engineering staff and Research Laboratory are at your service.

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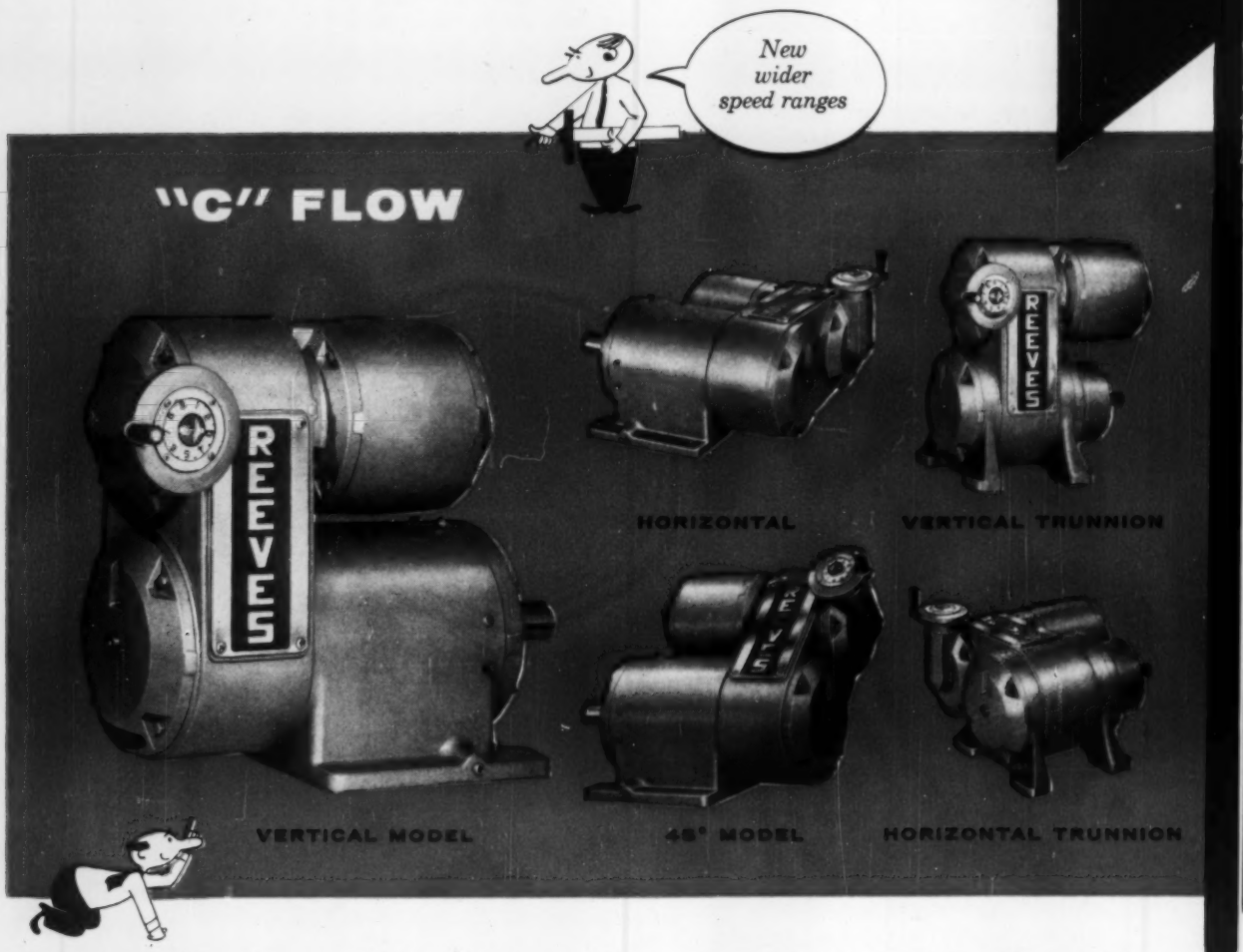
Home of the SUPERGAUGE ®

MORE THAN 50,000 TYPES OF GAUGES • SUPERGAUGES • SOLID FRONT GAUGES • RECEIVER GAUGES • TEST GAUGES • RECORDERS • CONTROLLERS • TRANSMITTERS • PSYCHROMETERS • AVIATION INSTRUMENTS

Circle 471 on page 19

variable speed with new versatility and performance



A triumph of new Motodrive design . . . inside and out

New REEVES Vari-Speed Motodrives, sizes 200 and 300, are complete variable speed power packages, built with compactness and precision, to give improved performance on installations 1 through 5 hp.

The new sizes are designed in two styles—"C" flow and "Z" flow. In each style, there are several different models and reducers with increased capacity in single, double or triple stages.

The flexible design permits hundreds of combinations . . . space-saving, space-fitting *standard* assemblies to meet most installation requirements.

The handwheel control location can be rotated to optional positions for greater operating convenience; extra precision of control is available with the addition of one or more REEVES accessories or modifications.

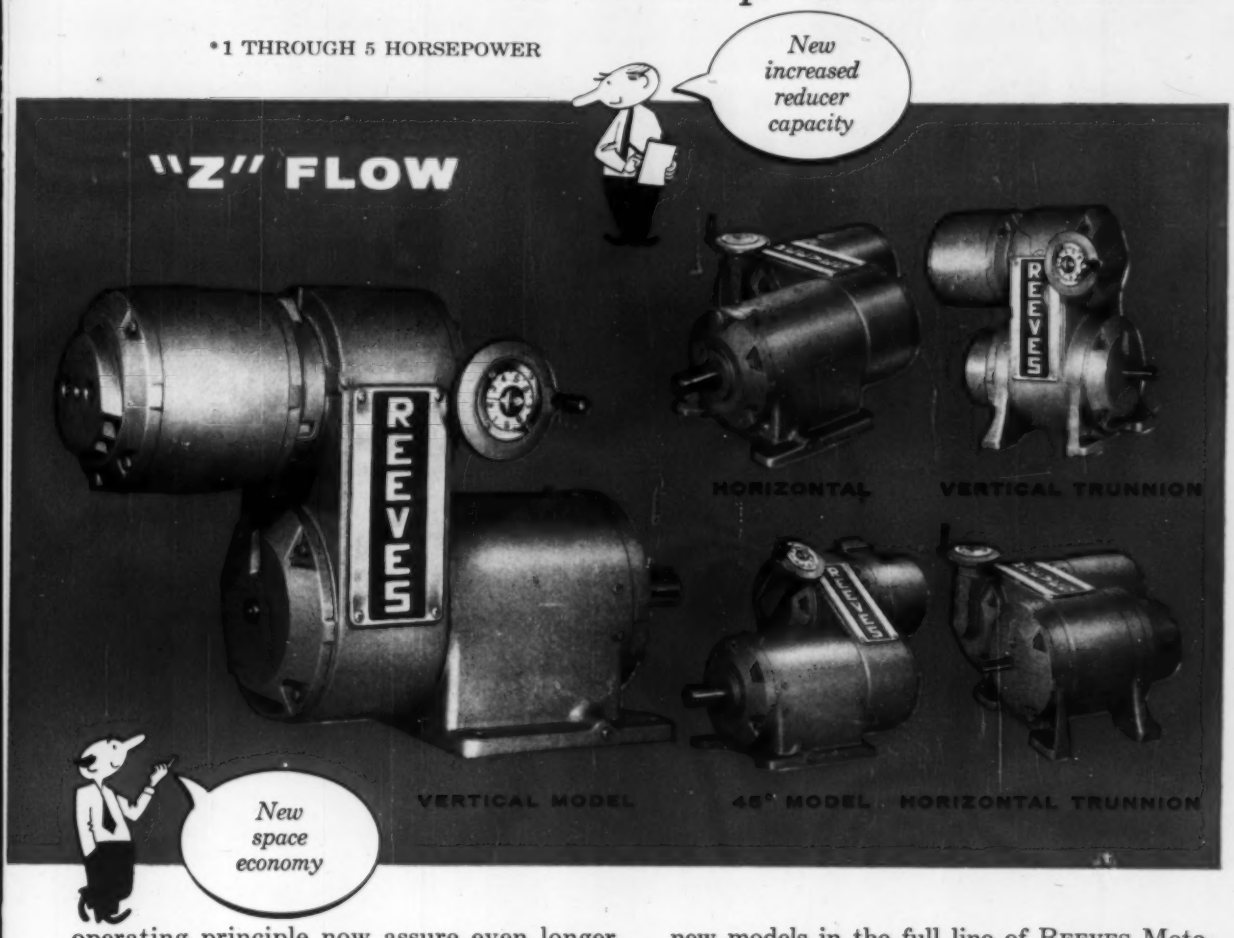
Refinements to the time-tested REEVES

NEW

REEVES®

*Sizes 200-300 Vari-Speed MOTODRIVES**

*1 THROUGH 5 HORSEPOWER



operating principle now assure even longer trouble-free service.

New disc assemblies permit wider output speed ranges . . . discs are pre-aligned . . . pre-loaded spring maintains correct belt tension for longer belt wear . . . *exclusive* "close-grooving" lubrication assures free sliding discs . . . new Metermatic system automatically lubricates the motor and variable shaft bearings.

Sizes 200 and 300 are versatile, hard-working new models in the full line of REEVES Motodrives which provide instant and accurate variable speed control on ¼ through 40 hp. applications.

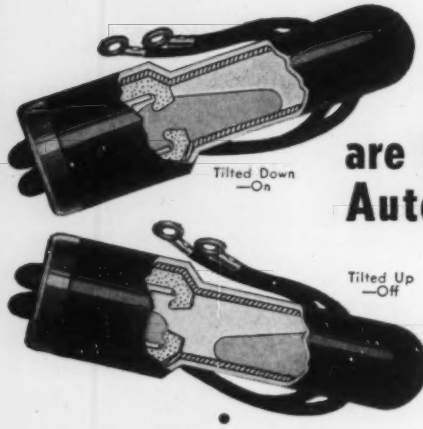
Complete details, dimensions, illustrations and prices on assemblies, modifications and accessories are in Catalog H31-M571. Write for your free copy today.

REEVES PULLEY COMPANY

Division of **RELIANCE** ELECTRIC AND ENGINEERING CO.

Columbus, Indiana

Circle 472 on page 19



DURAKOOL Tilt Switches are the Life of your Automatic Controls

MILLIONS OF CYCLES WITHOUT FALTERING

This steel-clad Durakool mercury tilt switch has unique construction features that deliver years of trouble-free performance on the most difficult assignments you can find. Operating under sealed-in, pressurized hydrogen gas, it takes 24 hours, fast cycling schedules in stride. 7 sizes, 1 to 65 amperes. Send for Bulletin 525.

See telephone directory for local distributor, or write.

DURAKOOL, INC.

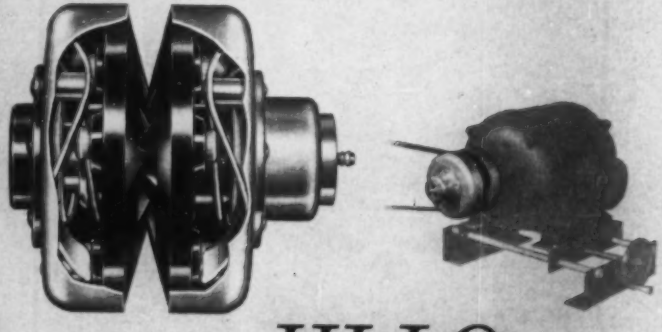
ELKHART, INDIANA, U.S.A.

700 WESTON RD., TORONTO 9, CANADA

Durakool ALL-STEEL MERCURY *Switches*

Circle 473 on page 19

striving for SIMPLICITY?



here's how HI-LO *helps*

Design-wise, HI-LO automatic variable speed pulleys help you reduce complex design problems. Functionally, they're first choice of many design engineers for a wide range of applications. The simple, positive action of cam followers on cams is the mechanical action that takes place in maintaining the pitch diameter setting regardless of load—an exclusive feature of HI-LO pulleys. Springs in HI-LO pulleys are not driving members as in most spring-loaded pulleys, but serve primarily to keep the pulley faces in contact with the belt.

For *FREE* technical manuals with diagrams, descriptions of applications and other power transmission data, write:

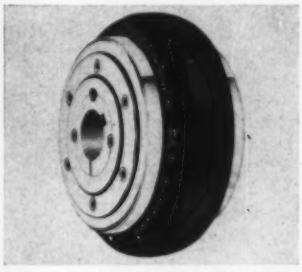
Equipment Engineering Company

2855 Columbus Ave., Minneapolis, Minnesota

Circle 474 on page 19

New Parts

(*Continued from Page* 133)



split in tire permits easy installation and makes replacement possible without moving driver or driven machine. Coupling takes angular misalignment to 4 deg, parallel misalignment to ⅛-in. and end-float to 5/16-in. individually or simultaneously. Unit requires no lubrication. It is available in capacities to 600 hp at 900 rpm. **Dodge Mfg. Corp.**, Mishawaka, Ind.

Circle 616 on page 19

Transistor Clips

of tempered beryllium copper

Transistor clips retain transistors under conditions of severe acceleration, deceleration, shock and vibration. Of tempered beryllium copper, clips perform dual function of retention and heat dissipation. They are available in cadmium, black ebanol or silver

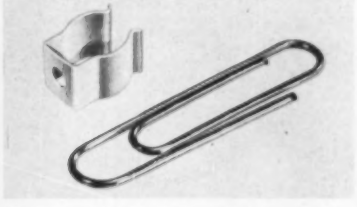


plate in many sizes and modifications. **Birtcher Corp.**, Industrial Div., 4371 Valley Blvd., Los Angeles 32, Calif.

Circle 617 on page 19

Directional-Control Valve

for fluid-power circuits

Hydreco directional-control valve has a capacity of 150 gpm at 2000 psi. It is equipped with three plungers which control single or double-acting cylinders for operation of heavy-duty earthmoving

BUILT BY ENGINEERS

WHO SPECIALIZE IN

FLOW REGULATORS

Waterman Engineering Company has furnished thousands of flow regulators to all types of industries with growing satisfaction.

Their experience in this field is most valuable in accumulating a fund of data on flow control applications. Waterman offers you this experience in solving your flow control problems. Only a few of Waterman models are shown on this page.

Write for latest bulletin F

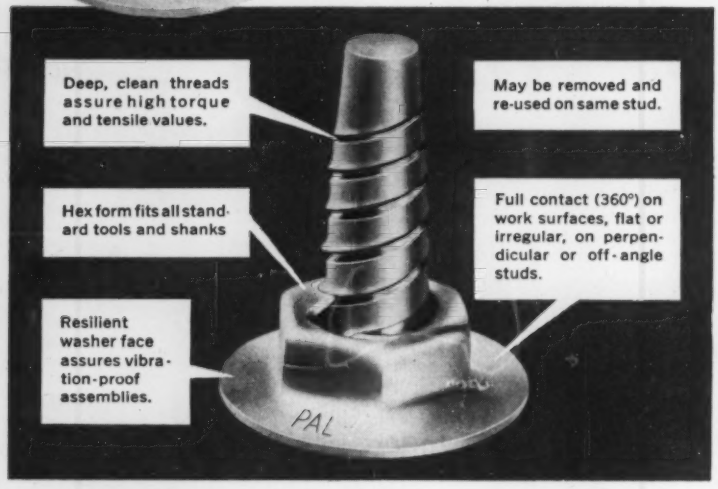
WATERMAN ENGINEERING COMPANY

725 CUSTER AVENUE • EVANSTON, ILLINOIS

Circle 479 on page 19

New! PALNUT®
SELF-THREADING NUTS

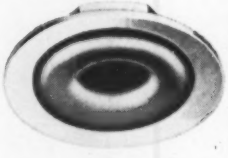
Make their own threads on studs — easily, quickly


Deep, clean threads assure high torque and tensile values.
May be removed and re-used on same stud.
Hex form fits all standard tools and shanks
Full contact (360°) on work surfaces, flat or irregular, on perpendicular or off-angle studs.
Resilient washer face assures vibration-proof assemblies.
PAL

Ideal for Nameplates — Ornaments — Moldings with die-cast or cold-forged studs

Now . . . low-cost, plain studs become strong, vibration-proof threaded assemblies by simply fastening with the new PALNUT Self-threading Nuts. You eliminate the high cost of threaded studs—your fastening operation does the thread-cutting while tightening. No special tools needed—high-speed assembly is obtained with standard tools and methods.

PALNUT Self-threading Nuts are made of spring-tempered steel, comprising a thread-cutting lock nut and flat washer in one piece. Parts are pulled up tight with a resilient spring locking action that will not loosen in service. Available in sizes for 1/8", 3/16" and 1/4" unthreaded studs. Write for free samples and descriptive literature.



Also available with "bonded-in" plastisol compound to seal out water and dust.

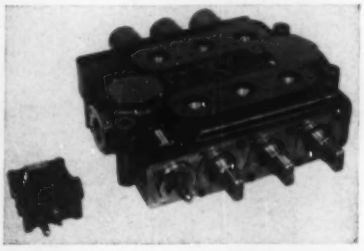
THE PALNUT COMPANY, 75 Glen Road, Mountainside, N. J.
Subsidiary of United-Carr Fastener Corporation

PALNUT® LOCK NUTS FASTENERS PAL®

Quick, secure fastening at low cost

New Parts

and large-capacity materials-handling equipment. Valve incorporates a hollow-plunger design which provides a check valve built into control plunger to prevent



back flow from cylinders when operating positions are being changed. Built-in relief valve protects fluid-power system from overload. **New York Air Brake Co.,** Kalamazoo Div., Kalamazoo, Mich.

Circle 618 on page 19

Motors

meet all NEMA standards

Spacesaver motors are available in single, two and three-phase types. Single-phase models are constant speed, drip-proof and enclosed fan-cooled units with ratings from 1/2 to 3 hp. Two and three-phase units are available with 1/2 to 5 hp ratings. Motors meet all NEMA

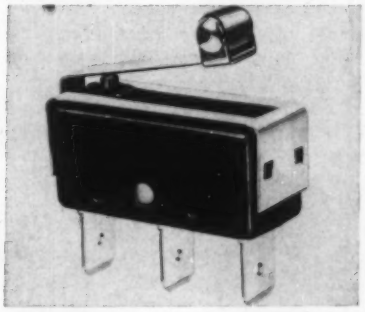
standards. They have prelubricated double-shielded type ball bearings. **Peerless Electric Co.,** 1435 E. Market St., Warren, O.

Circle 619 on page 19

Snap Switches

miniature units are designed for ganging

Class-4 TyniSwitches are for applications that require high electrical rating in a small precision unit. Designed for ganging, they offer



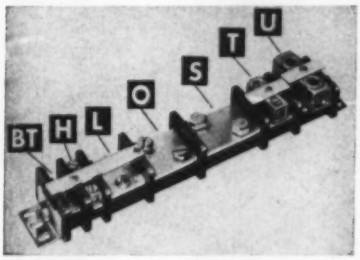
operating forces from 3 to 12 oz on the pin, and are available with solder, screw, standard spade or tab terminals. Rated 15 amp, 125-250 v ac, switches are available in four models: spring-leaf and roller actuated; pin-actuated; spring-leaf actuated; and rotary actuated. **Detroit Controls Corp.,** TyniSwitch Dept., 800 Union Ave., Bridgeport, Conn.

Circle 620 on page 19

Terminal Block

handles 30 to 250 amp

Combination terminal block permits grouping any combination of seven different types of terminals in a single block. Terminals with



capacities from 30 to 250 amp are assembled in the combination required. Block utilizes standard components. **Curtis Development & Mfg. Co.,** 3250 N. 33rd St., Milwaukee, Wis.

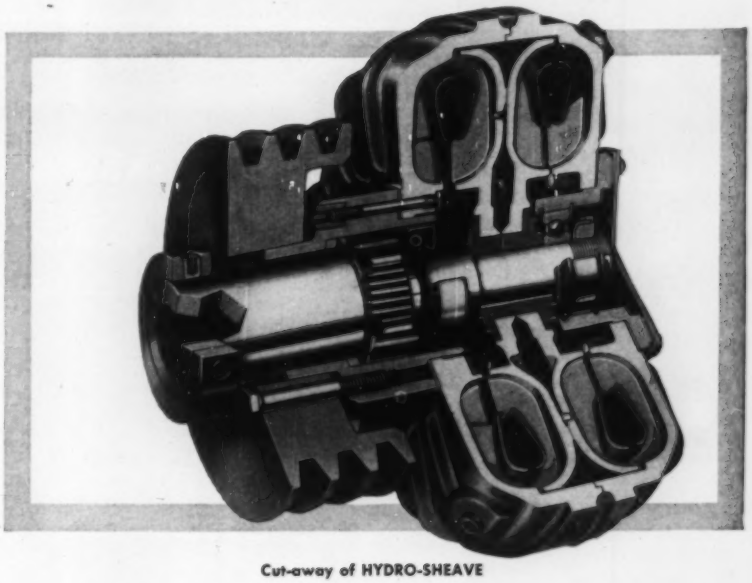
Circle 621 on page 19

Battery Connector

for service to 28 v dc

Moisture-sealed, single-pole battery connector, for service to 28 v dc, 300 amp, is available in CA21985 90-deg plug and CA21986 receptacle. Receptacle is panel-mounted and incorporates O-ring

Here's why machinery lasts longer *WHEN POWERED THROUGH FLUID*



Cut-away of HYDRO-SHEAVE

Wherever you find shock loads, torsional stresses or vibrations, you can bet both driving and driven equipment will show undue wear.

That is, *unless the power is transmitted through fluid!*

With Twin Disc Fluid Couplings and HYDRO-SHEAVE® Drives, there are no mechanical connections between driving and driven equipment . . . no metal-to-metal contact to transmit destructive shocks and vibrations. These, instead, are absorbed in the fluid—not in your machinery's expensive components.

But that's not all. Twin Disc Fluid Couplings and HYDRO-SHEAVE Drives offer such advantages as—

1. **Reduce motor starting current demands . . . provide smooth, fast acceleration . . . and often improve over-all power factor.**
2. **Protect against overloads, stalling and motor burn-outs.**
3. **Transmit full input torque at all output speeds.**
4. **Permit motor selection based on running rather than starting load.**
5. **Are engineered as a "package" . . . can be installed in minutes on any standard keyed shaft.**
6. **Because of fluid connection, *cannot* wedge or "freeze" internally.**

Twin Disc HYDRO-SHEAVE Drives—¾ to 50 horsepower; Fluid Couplings—¾ to 850 horsepower.

TWIN DISC

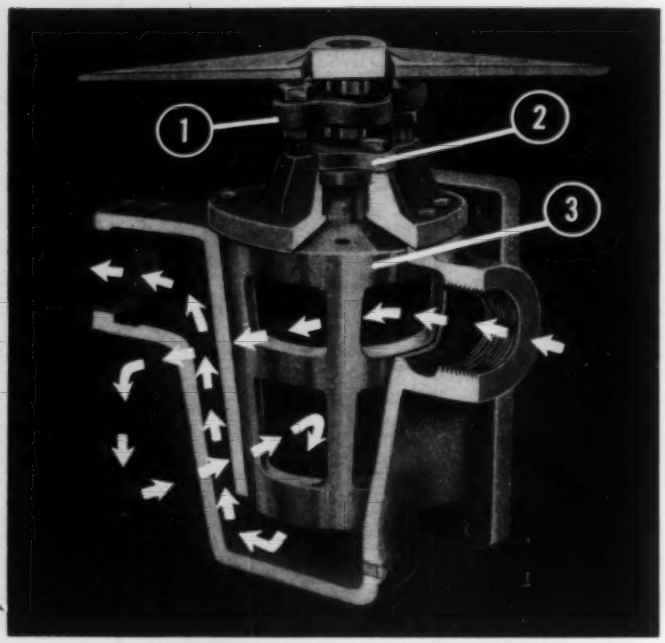
TWIN DISC

Friction Clutches and Fluid Drives

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • HYDRAULIC DIVISION, Rockford, Illinois

Branches or Sales Engineering Offices: Cleveland • Dallas • Detroit • Los Angeles • Newark • New Orleans • Tulsa

Circle 477 on page 19



(1) Locking flange (2) Gland (3) Valve plug

NEW! KRAISSL Class 72 Valve

Simplifies Control of Non-Interrupted Flow

Originally designed and job-proven as the center section of our own Class 72 separator, this valve permits diversion of 2-way flow from one chamber to another—*without shutting down.* The single-unit installation eliminates costly, cumbersome piping and fittings.

Simple, hand-turning of tapered, non-wedging valve plug re-routes flow into alternate chamber or system. Continuous-flow design of valve plug *absolutely insures against shut-off.* The Class 72 valve assembly is ideal for heat exchanger and similar applications where uninterrupted flow is mandatory.

Pressure ratings to 600 psig with standard line; Special valves for higher pressures.

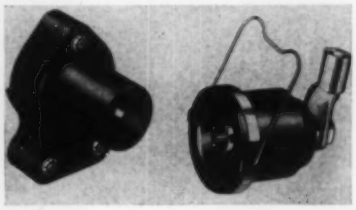
Write for technical bulletin A-1869

KRAISSL CO

292 WILLIAMS AVE., HACKENSACK, N. J.

New Parts

moisture seals on both sides of panel and about contact of mating plug. It contains a bail latch that permits plug to rotate 360 deg when mated and latched. Current-carrying components are heavy



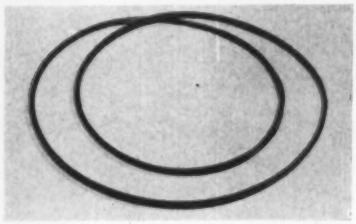
gold plated over silver, and allow choice of cable termination, pin or rocket ends. Socket terminal ends are designed for a No. 1/0 terminal lug. **Cannon Electric Co.,** 3208 Humboldt St., Los Angeles 31, Calif.

Circle 622 on page 19

Rubber Rings

are lathe-cut

Lathe-cut rubber rings, produced in standard elastomers or special compounds, are available in diameters of 5 in. and over. Rings meet all AMS and MIL specifications. Accuracy to ±0.008-in. is main-



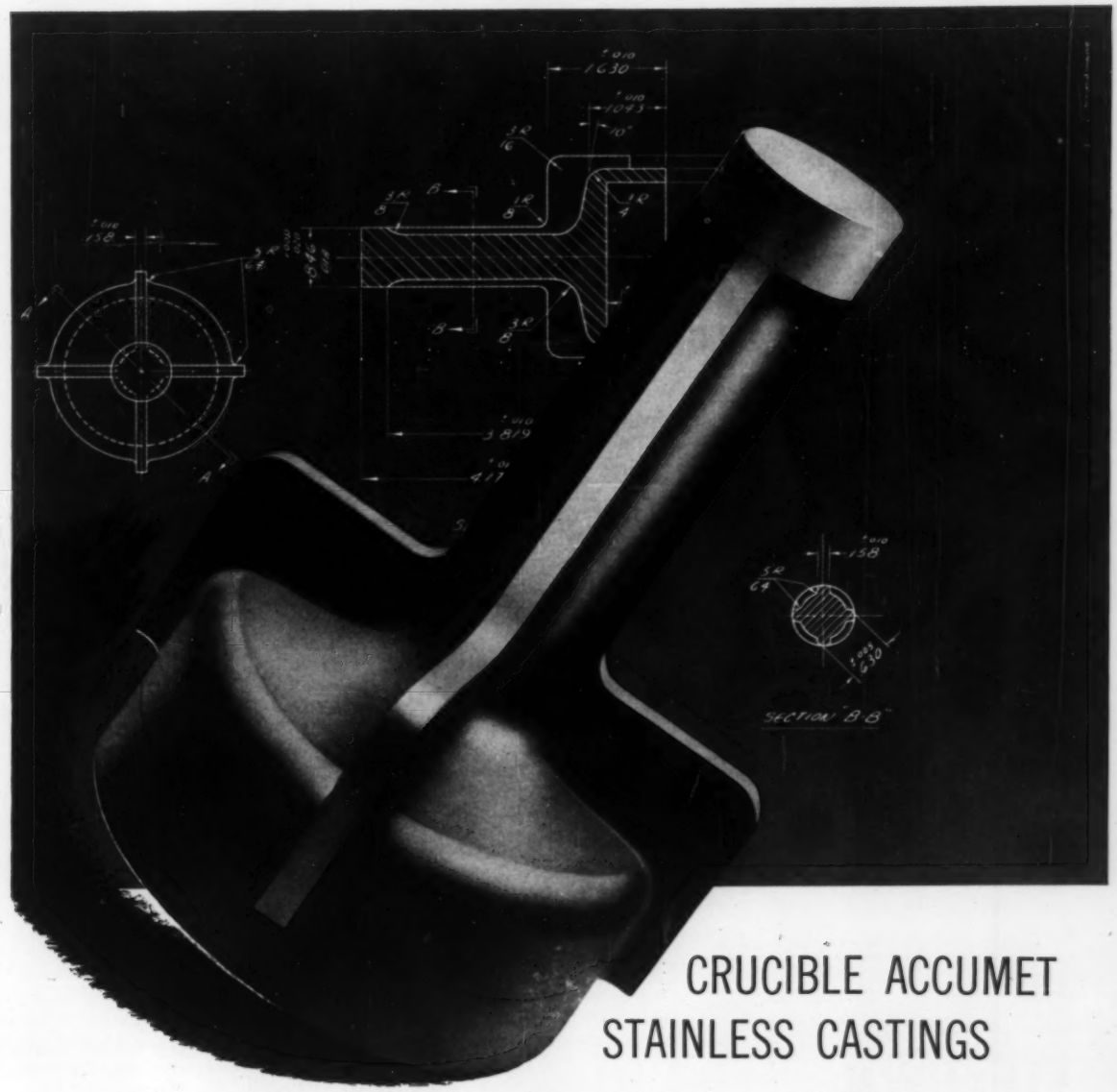
tained in large production runs. Rings have a high mirror finish on the OD and ID and have sharp edges. Matte-finished, slightly rounded edges are also available. **Acushnet Process Co.,** New Bedford, Mass.

Circle 623 on page 19

Recorder-Totalizer

for systems and procedures control

Model SR recorder-totalizer accumulates data on the operation of machines, processes or systems. Continuous sprocket-driven strip



CRUCIBLE ACCUMET STAINLESS CASTINGS

provide smoother surfaces . . . closer tolerances — cut finishing costs

Even intricately shaped parts, like this cream separator neck piece, can be used essentially as-cast when produced by the ACCUMET method. That's because ACCUMET casting employs hot molds with special inner linings. You get castings on which thin sections are minutely defined . . . and with exceptionally fine surface finish. *Costly finishing operations are practically eliminated.*

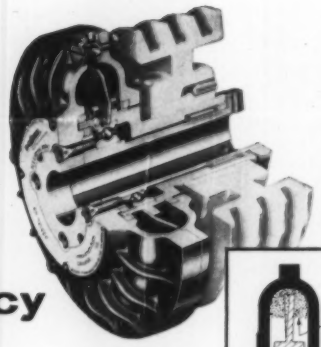
On this stainless steel part, for example, the only finishing operations necessary are drilling and tapping of the stem section, grinding flats on the bow end, and polishing.

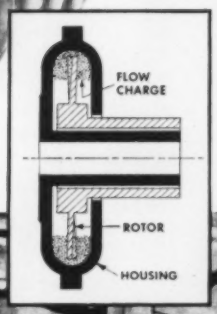
To minimize finishing operations on your products, consider the advantages of ACCUMET precision investment castings. Let your Crucible representative show you how their close tolerances, fine finish, and physical and metallurgical accuracy can spell substantial savings for you. And — to see what information is available on these and other Crucible special steels, write for your free copy of the "Crucible Publication Catalog." *Crucible Steel Company of America, Henry W. Oliver Building, Pittsburgh 22, Pa.*

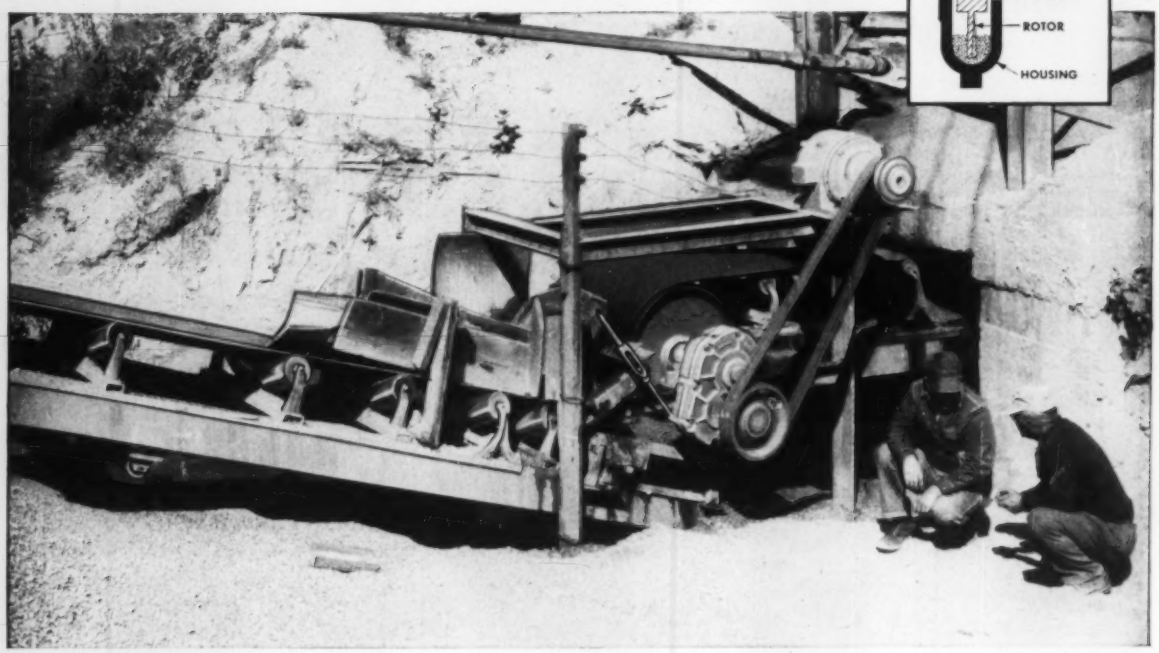
CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

This new drive starts loads smoothly... with smaller motors ...and gives 100% efficiency at full load!







FLEXIDYNE

THE DRY FLUID DRIVE

This tunnel conveyor, 225 feet long, handles 500 tons of sand and gravel per hour—8 to 16 hours a day.

With Flexidyne, the motor picks up the load easily and smoothly. Power investment is reduced, power costs cut, maintenance simplified and conveyor belts are protected against breakage.

Flexidyne, the Dry Fluid Drive, is the *new* development that starts loads smoothly, that protects against shocks and overloads, that saves power and that gives 100% efficiency at full load!

The "dry fluid" in Flexidyne is heat treated steel shot. A measured amount, called the flow charge, is contained in the housing, which is keyed to the motor shaft. When the motor is started, centrifugal force throws the flow charge to the perimeter of the housing, wedging it between the housing and the rotor which transmits power to the load.

After a momentary slip between housing and rotor, the two become locked together and achieve full load speed without slip and at 100% efficiency during the running cycle. Changes in weather—hot or cold—inside or out—do not affect operation of Flexidyne.

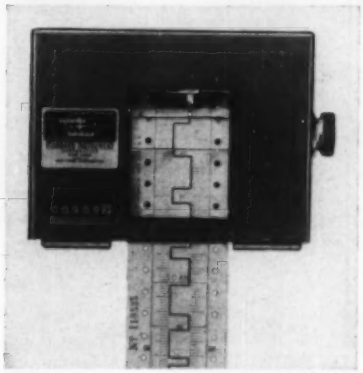
Flexidyne is now available in 8 sizes—for use with electric motors and internal combustion engines from 1 hp to 300 hp. While each size is power rated, the flow charge can be varied at will to give tailor-made torque for your particular job. Write for Bulletin A-640.

DODGE MANUFACTURING CORPORATION
3300 Union Street, Mishawaka, Indiana

CALL THE TRANSMISSIONEER, your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look for his name under "Power Transmission Machinery" in in your classified phone book, or write us.

DODGE
of Mishawaka, Ind.

chart maintains positive, accurate timing. Speeds from 1 in. per hr to 10 in. per minute are available. Time totalizer registers in either hours and tenths or minutes and tenths. Stylus provided with each chart roll provides a clearly de-



fined line. Transparent window allows viewing of recorded chart. It can be lifted for making notations directly on chart. Chart time-setting knob provides means for setting chart to correct time of day. **Standard Instrument Corp.**, 657 Broadway, New York 12, N.Y.

Circle 624 on page 19

Molded Teflon Shapes

have cross-sections of 1/16-in. or less

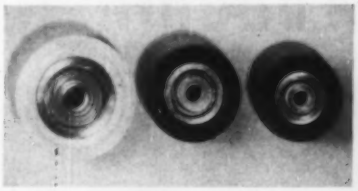
Teflon shapes, such as cup seals, piston wipers, ball seals, valve and shaft seals, diaphragms and gaskets, are available with cross-sections of 1/16-in. or less. Articles are produced by a new process and have no loss of uniformity or tolerances and are free from cracks. Effect of plastic memory is minimized, waste of material is avoided, and mass production is achieved at reduced costs. **Sparta Mfg. Co.**, Dover, O.

Circle 625 on page 19

Bearings

have nonmetallic outer race

Stud, bore, flange and special bearings are available with Nylon, rubber or laminated phenolic tires which reduce noise factors during operation. Outer race materials are molded or pressed fit to basic steel outer race, providing wear-



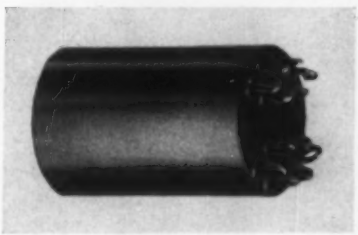
ability of steel plus silent operation of rubber, Nylon or phenolic. **General Bearing Co. Inc.**, 47 Roselle St., Mineola, N.Y.

Circle 626 on page 19

Miniature Relay

resists high-g forces, vibration and heat

Electromagnetic actuating mechanism is a balanced rotary system with highest torque at application of current. Unit has maximum resistance to *g* forces and vibrations. Magnetic force moves, dampens and stops armature. Standard units operate at tempera-



tures to 300 F. Actuating current is either 24 to 28 v dc or 115 v, 400 cycles ac. Hermetically sealed container is filled with neutral gas. **Nemeth Inc.**, 2223 S. Carmelina Ave., Los Angeles 64, Calif.

Circle 627 on page 19

Heat Exchangers

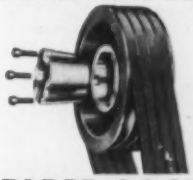
for lubricating oil and water cooling

Hi-transfer exchangers assure maximum heat transfer with minimum pressure drop. Shell and tubes are for working pressures of 75 psi and are tested at 115 psi. Units are designed for cooling lubricating oil and water on machinery. Parts and exchanger units are interchangeable to permit rapid installation. Bronze bonnets and tube sheets, seamless copper shells and brass baffles provide

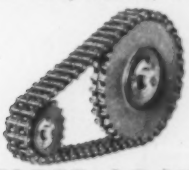
(*Continued on Page* 146)

DODGE PRODUCTS you should know

TORQUE-ARM
SPEED REDUCERS
Cost less—deliver more!



TAPER-LOCK
SHEAVES
Easy on—easy off! Mount flush!



TAPER-LOCK
SPROCKETS
No reboring—no waiting!

Write for Bulletins!

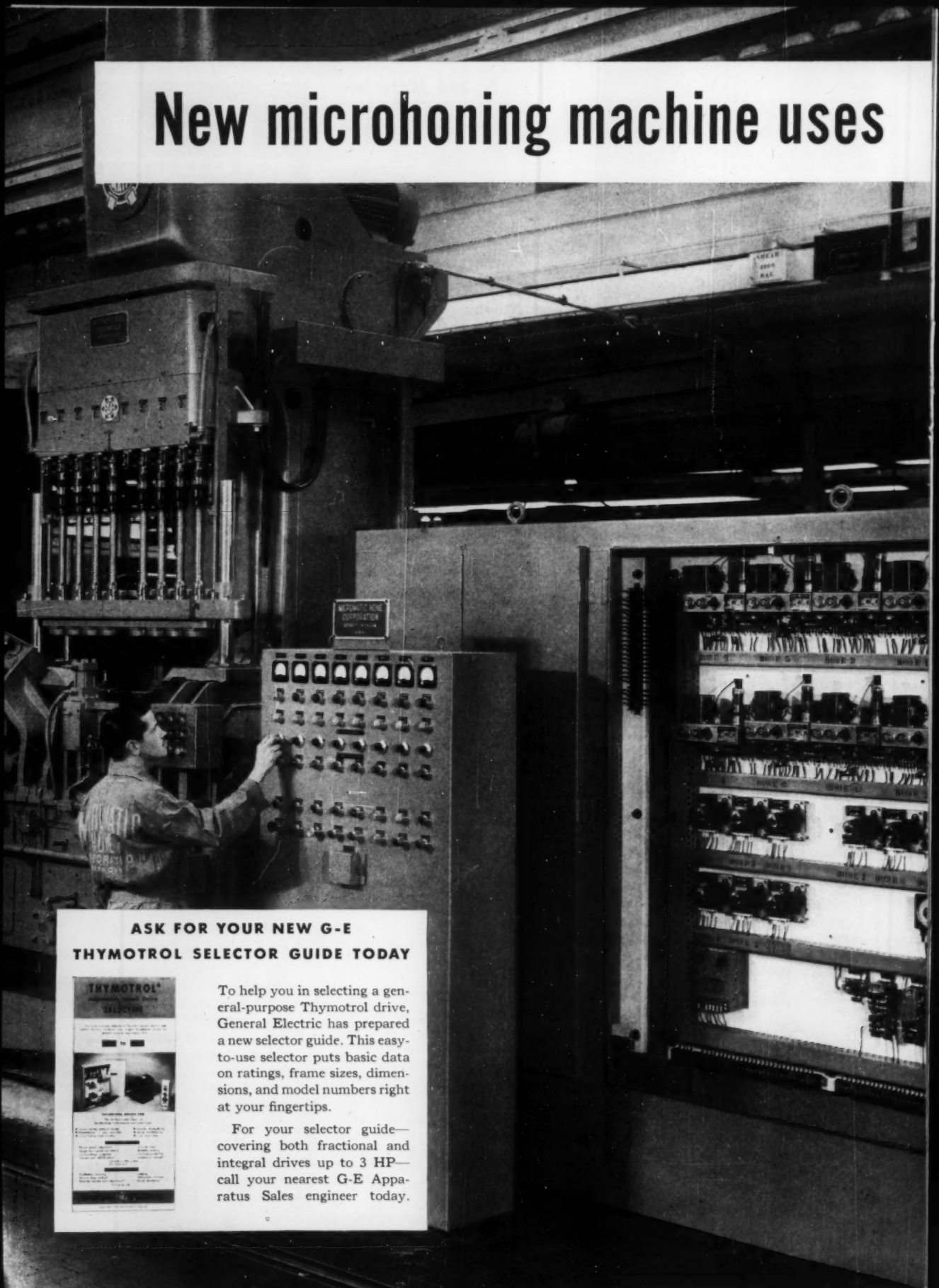
- Torque-Arm Speed Reducers. 15 sizes—1 to 100 hp. Bulletin A-637
- Taper-Lock Sheaves. Drive tables and technical data. Bulletin A-661
- Taper-Lock Sprocket and Dodge Roller Chain data. Bulletin A-644

DODGE MANUFACTURING CORPORATION
3300 Union Street • Mishawaka, Indiana

DODGE
of Mishawaka, Ind.

Circle 511 on page 19

New microhoning machine uses



ASK FOR YOUR NEW G-E THYMOTROL SELECTOR GUIDE TODAY

To help you in selecting a general-purpose Thymotrol drive, General Electric has prepared a new selector guide. This easy-to-use selector puts basic data on ratings, frame sizes, dimensions, and model numbers right at your fingertips.

For your selector guide—covering both fractional and integral drives up to 3 HP—call your nearest G-E Apparatus Sales engineer today.

General Electric Thymotrol* drives to speed cutting, boost accuracy

Eight General Electric general-purpose Thymotrol drives—costing up to $248† *less* than other electronic adjustable-speed drives—are precisely controlling the expansion motions of Micromold tools on Micromatic's new machine.

Micromatic Hone Corporation formerly used only hydraulic control in this operation. Now, with G-E Thymotrol drives, they are able to utilize a new type of tool resulting in greater accuracy, improved cutting action, and easier remote operation—*all* at low initial investment.

This is but one of the wide range of G-E general-purpose Thymotrol applications. Today, these job-tailored drives are being used on transfer machinery, machine tools, process pumps, testing equipment—in fact—they are being applied to almost any machine whose performance can be improved with adjustable speed.

OUTSTANDING BENEFITS

Backed by years of leadership in the design, manufacture, and application of adjustable-speed drives, General Electric Thymotrol drives offer:

Increased production—right speed provided for every requirement.

Increased machine versatility—wide speed range and close speed regulation permit use of same machine on a variety of work.

Reduced downtime, lower maintenance—design features such as swing-out panels, readily accessible components make maintenance a fast, simple job. Beyond normal lubrication, little maintenance is required since there are no moving parts in the control to wear out or break down.

All G-E general-purpose Thymotrol panels have a written one-year warranty—an expression of G.E.'s confidence in their reliability.

SELECT THE DRIVE YOU NEED —AND SAVE MONEY!

When you select Thymotrol drives you get the perfect combination—*outstanding performance at low price.* See your G-E Apparatus Sales engineer today or write for Bulletins GEA-6234 and GEA-6519 to Sect. 791-4, General Electric Co., Schenectady 5, N. Y. *Specialty Control Dept., Waynesboro, Va.*

*Reg. Trade-mark of General Electric Company.

†1/10 HP, 220-volt AC input, general-purpose Thymotrol drives.

Progress Is Our Most Important Product

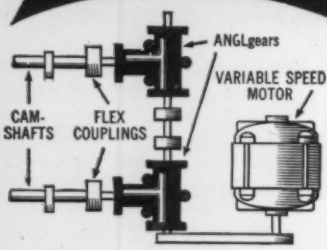
GENERAL ELECTRIC

COMPARE AND PROVE GENERAL ELECTRIC'S SUPERIORITY

FEATURES	G-E THYMOTROL DRIVE	DRIVE A	DRIVE B	DRIVE C	DRIVE D
Speed range of 20 to 1 or more	✓			✓	✓
Printed circuitry	✓		✓		
Flat regulation at any pre-set speed	✓		✓		
Current limit acceleration	✓				
Regulation of 5% or less	✓		✓	✓	
Quick slowdown	✓	✓			
New NEMA motor sizes	✓				

Circle 481 on page 19

ANGLgear solves timing problem



Drawing based on actual installation shows ANGLgear drives for camshafts on Herb-Shelly bagmaking machine. ANGLgears provide positive power transmission; assure correct timing of cam action.

A producer of polyethylene packaging, Herb-Shelly, Inc., Farmington, Minn., designs and builds much of its own production equipment.

One machine, an automatic bagmaker, required 90° power takeoffs to drive its two parallel camshafts. Chains and sprockets were rejected because even the slightest backlash would have affected timing. Miter gears were used instead. However, they failed repeatedly under the constantly fluctuating load imposed by the cams.

Finally, Herb-Shelly installed two standard ANGLgears. Result: the ANGLgears not only provided the positive, precision drive essential for accurate timing, but also, unlike previous bevel gears, had the stamina to absorb the continuous variations in load.

Perhaps ANGLgear can solve a similar 90° drive problem for you. ANGLgears are available from stock in 3 sizes; 12 models.

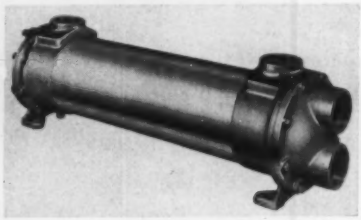
See our literature in Sweet's Product Design File; then contact your local distributor or write direct.

AIRBORNE®
AIRBORNE ACCESSORIES CORPORATION
HILLSIDE 5, NEW JERSEY

Circle 482 on page 19

New Parts

(*Continued from Page* 143)



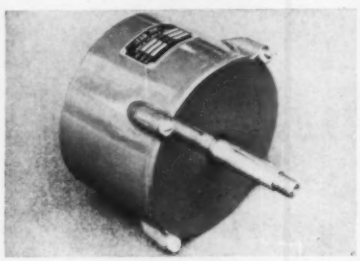
maximum corrosion resistance. **Whitlock Mfg. Co.**, 101 South St., West Hartford 14, Conn.

Circle 628 on page 19

Alternators

rated 500 to 4500 va

Permanent-magnet alternators provide durability and reliability, excellent wave form, and ability to recover from dead shorts without any effect on voltage or performance. Used in aircraft, guided-missile, automotive and industrial applications, the generators can be driven by electric motors, air drives, turbines, and two and four-cycle gasoline engines. Units are available for most standard voltages, 400-cycle, single-phase, or three-phase, either wye or delta-connected. Other configurations include compound units, two-bearing-type units, and units with standard AN pads for hydraulic motor drives. Output ratings range from 500 to 4500 va. **Lear Inc.**, LearCal Div., 3171 S. Bundy, Santa Monica, Calif.



Circle 629 on page 19

Sixty-Cycle Chopper

has high vibration and shock resistance

Microverter 60-cycle chopper converts a low-level dc signal into a low-level ac signal which can be further amplified to operate various control apparatus in null bal-

precision

PRESSURE REGULATORS

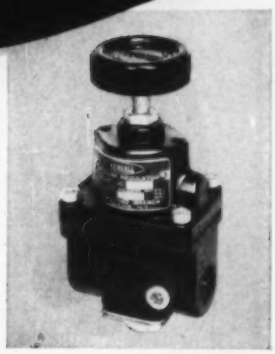
14 models to meet almost all industrial needs

Send for catalog

Now available from the Stratos Industrial Products Branch are two complementary lines of pneumatic pressure regulating valves.

The pilot-operated GOVERNAIRE: very high flows are regulated by small signals in these self-contained, pilot operated models. Up to 250 psi supply pressure, pipe sizes from ¼ to ¾ NPT.

Drift-free, lever set model 3500

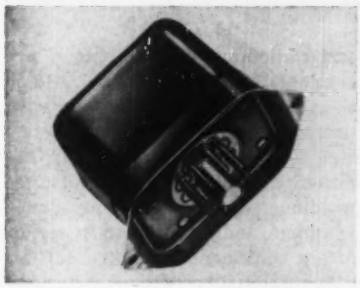


The direct acting KENDALL: also available in a wide flow range, these force-balanced types are designed for operation at up to 250 psi supply pressure. Pipe sizes from ¼ to ⅜" NPT.

STRATOS
INDUSTRIAL PRODUCTS BRANCH
A division of Fairchild Engine and Airplane Corp.
Route 109, West Babylon, N. Y.

Circle 510 on page 19

ance servo systems, industrial instruments, and other automatic controls. It is also used as a synchronous rectifier to convert low-level ac signals to dc without loss. Chopper shows excellent stability under shock and vibration. Service life is 10,000 hr at contact



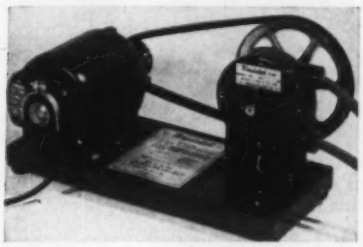
load of 1 ma at 1 v dc resistive. **Barber - Colman Co.**, Electrical Components Div., 1400 Rock St., Rockford, Ill.

Circle 630 on page 19

Corrosionproof Pump

handles abrasive liquids and slurries

Pump handles all types of abrasive solutions and slurries with minimum maintenance. Intake and outlet are one continuous flexible tube which passes through pump body where it is exposed to the action of a rotary squeegee. Unit is for pumping cutting and cooling fluids where abrasive particles of a size not easily held by a strainer



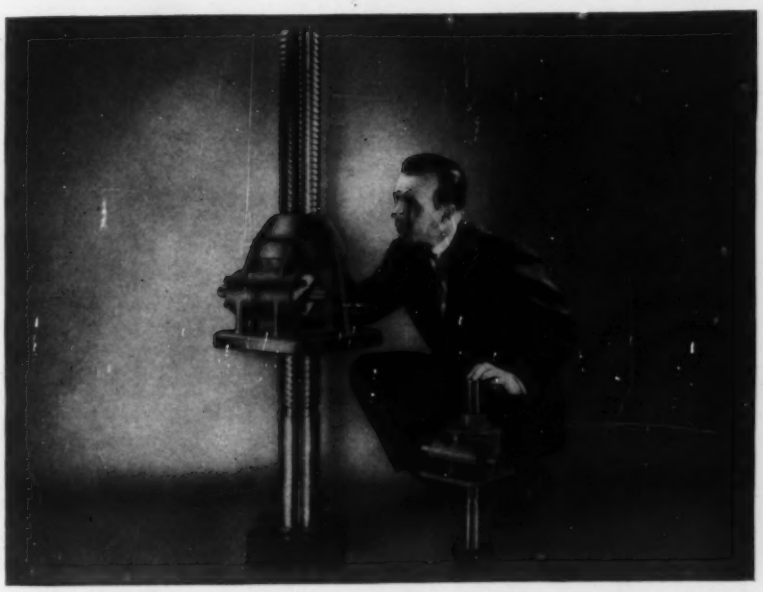
are present. Action is quiet and capacity uniform. **Randolph Co.**, 1018 Rosine St., Houston, Tex.

Circle 631 on page 19

Assembly Bits

for magnetic shift registers

Individual assemblies for custom fabrication of magnetic shift registers for computing, telemetering



Here's A Device Every Machinery Designer Should Know About . . .

It's the Duff-Norton Worm Gear Jack, successfully used by many machine builders as a component of equipment for precise, positive control of linear motion, applying pressure, resisting impact. Two or more of these jacks can be connected by means of shafting and mitre gear boxes to give a positive drive, so that jacks always raise or lower under equal or unequal loads in perfect unison. Capacities range from 5 to 50 tons with any raise up to 25 inches; worm gear ratios, 6¾:1 to 27:1; turn of worm for each 1-inch raise, 10 to 40; available in either Acme or square threads. For protection against foreign matter certain models can be furnished with bellows boots.

Thousands of these jacks are in use today for table adjusting—machine adjusting—rolling mill adjusting—raising and lowering conveyors, machine beds, molds and dies, furnace lids, loading platforms, loading racks, gates, hinged mechanisms, arbor presses—adjusting electrodes—adjusting welding positioners.

Duff-Norton Worm Gear Jacks are available in 6 standard sizes. For complete specifications and detailed drawings, send for your free copy of a special brochure.

DUFF-NORTON Company

DUFF-NORTON COMPANY
Department MD
P.O. Box 1889, Pittsburgh 30, Pa.

Please send immediately a free copy of your new Worm Gear Jack Brochure.

NAME _____ TITLE _____

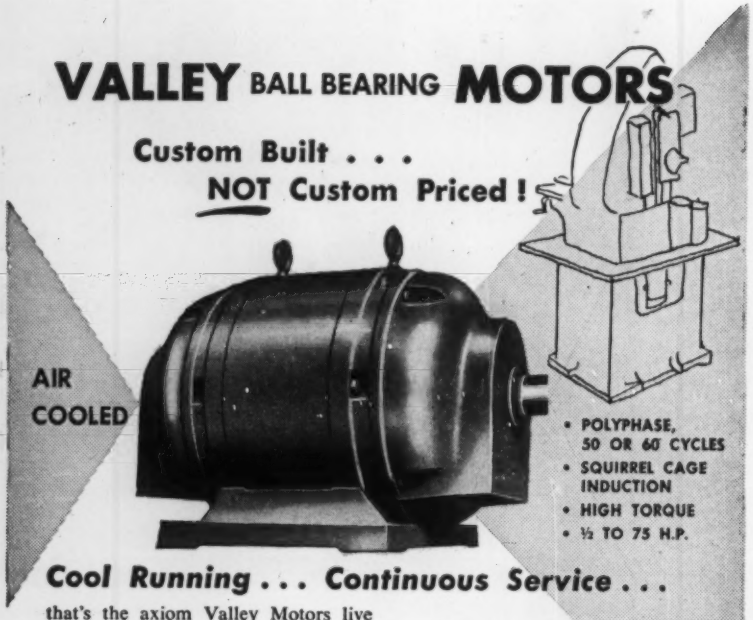
COMPANY _____ PHONE _____

ADDRESS _____

Circle 483 on page 19

VALLEY BALL BEARING MOTORS

Custom Built . . .
NOT Custom Priced!



Cool Running . . . Continuous Service . . .

that's the axiom Valley Motors live up to.

They have been tested and proven in every industry where dependable service and power is a requirement. Remember they are semi-enclosed to assure protection against dripping or splashing liquids, metal chips and abrasive dust.

WRITE FOR COMPLETE INFORMATION

VALLEY
ELECTRIC CORPORATION
4221 Forest Park Blvd. • St. Louis 8, Mo.

Circle 484 on page 19

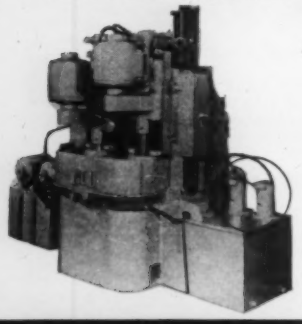
CONNECT THEM . . . FORGET THEM . . .

Ruthman Gusher COOLANT PUMPS

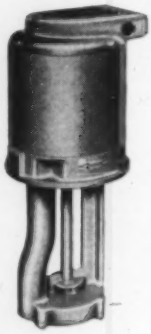
REQUIRE LITTLE MAINTENANCE

Ordinarily Gusher Coolant Pumps require no attention. Because there are no packing glands to adjust and they are equipped with heavy duty prelubricated for life, ball bearings. Your maintenance worries are minimized when you specify Gusher Pumps. **Write for our Catalog.**

THERE'S A GUSHER FOR EVERY REQUIREMENT



Illustrated is a Springfield Dual Spindle Vertical Grinder equipped with Gusher Coolant Pumps.



Model 6-P3 Immersed Type

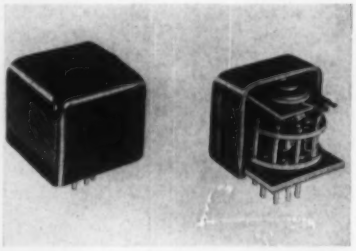
Ruthman MACHINERY CO.

• COOLANT PUMPS
• CIRCULATORS • AGITATORS
• MOLTEN METAL PUMPS

1811 Reading Road **Cincinnati, Ohio**

Circle 485 on page 19

New Parts

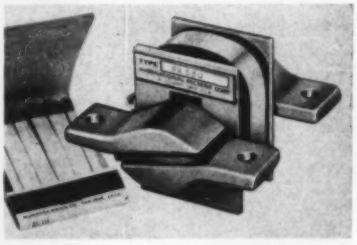


and communication equipment are available in two types. MRC-10 is a five-winding assembly with printed circuit base. It has two high - impedance windings in addition to input, output and advance windings. Use of high-impedance windings, individually or in series, offers additional flexibility. MRC-9 offers flexibility of a plug-in component as well as electrical versatility. It is a four-winding assembly for use in standard nine-pin miniature tube sockets. Using two assemblies per bit, unit cubes form a variety of shift-register configurations with serial and/or parallel read-in and/or read-out. **Magnetics Research Co.**, 255 Grove St., White Plains, N.Y.

Circle 632 on page 19

Paralleling Reactors

for heavy-current rectifiers



Type PR580 paralleling reactors insure equal distribution of current loads to germanium-rectifier junctions operating in parallel. No derating of junctions is required when reactors are incorporated in circuit, since they force each junction to share equal current load. Heat failure of junctions and overload due to unbalanced forward conduction is reduced. Units are rated at 580 amp rms for 50 C rise with normal convection cooling. **International Rectifier Corp.**, 1521 E. Grand Ave., El Segundo, Calif.

Circle 633 on page 19

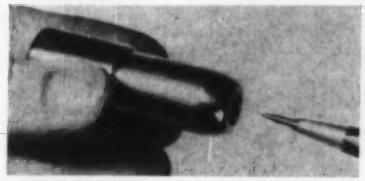
ENGINEERING DEPARTMENT

EQUIPMENT

Lead Pointer

accommodates all refill and pencil leads

Kleen-Point pocket lead pointer of anodized aluminum contains four tempered steel blades, interlocked to assure smooth, tapered points. It accommodates all standard refill and pencil leads. Drop-out core per-



mits easy replacement of blades, and graphite cup retains lead particles and unscrews for neat disposal. Unit is lightweight, is ¾-in. thick and 2½ in. long. **Alvin & Co. Inc.**, 853 Palisado Ave., Windsor, Conn.

Circle 634 on page 19

Drafting Triangles

in 12 to 24-in. sizes

Large Layout drafting triangles are of acrylic resin plastic in thicknesses from 0.080 to ⅛-in. Working edges are honed and chamfered for approximately 0.010-in. Corners are rounded to prevent injury and chipping. Triangles are available in 12 to 24-in. sizes, with larger sizes obtainable if required. **Dolgorukov Mfg. Co.**, 407 Fisher Bldg., Detroit 2, Mich.

Circle 635 on page 19

Wedge Analyzer

operates with up to three detectors at once

Model 201 Grey wedge analyzer is designed to analyze pulse spectrums from scintillation or proportional counters. Using Land-camera photography, a permanent card-sized photo record of spec-

Springs by the Millions

Accurate makes springs by the millions—many of our customers use a million a month. That takes a lot of spring know-how, experience and skill. But to produce precision springs in large quantities at nominal cost takes more than that. It takes imagination.

Imagination allows Accurate to approach problems without being too influenced by conventional methods. To successfully produce large quantities of precision springs Accurate customer service begins in the design and engineering stage. Highly developed skill in producing special tooling for large quantities often helps lower overall cost. Springs held to close tolerances are assured by rigid quality control and inspection. Packaging is designed to provide ease of handling and speed the customers' production. Scheduling and planning departments assure quantities delivered to meet your needs and reduce inventory requirements.

That is the type of experience, skill . . . and imagination, that allows Accurate to produce springs by the millions. Plan your springs with Accurate too.

ACCURATE SPRING MANUFACTURING COMPANY

3824 W. Lake St., Chicago 24, Illinois

SPRINGS • WIRE FORMS • STAMPINGS

power for hydraulic systems

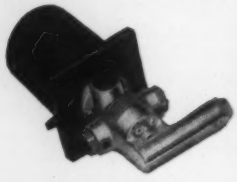
comes in small packages

Eastern Aviation Hydraulic Pumps are the smallest and lightest line of pumps ever made. They supply as much as one gallon of fluid per minute against pressures as high as 2000 PSI.

The 1700 Series of high speed gear pumps have theoretical displacements varying from .0091 to .1089 cubic inches per revolution. This series of pumps can be close-coupled directly to various electric motors. They are made in many configurations with and without integral bypasses. A variety of bearing combinations handle different types of fluids and operating pressures.

Eastern engineers can adapt and design hydraulic pumps to meet your specifications. On your next project, contact Eastern for engineering help that really helps.

Eastern 1700 SERIES PUMPS



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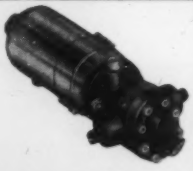
1731-LCU-205



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1700 SERIES PUMP

Send for Aviation Bulletin 340

Eastern INDUSTRIES, INC.

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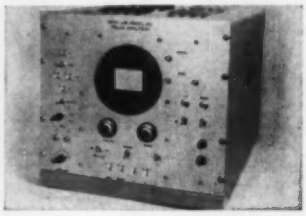
Engineering Equipment



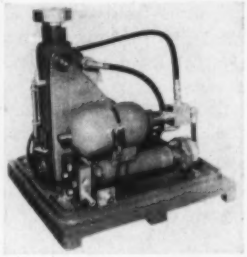
trum is available in minutes. Counting rate is up to 60,000 cps. **Beva Laboratory,** Box 478, Trenton, N. J.

Circle 636 on page 19

Hydraulic Exciter

has maximum force of 60,000 lb

Hydraulic vibration exciter is capable of sinusoidal motion at extremely high forces and large strokes. It has maximum force of 60,000 lb, available stroke of 4 in., and maximum velocity of 14 ips in the frequency range of 1 to 150 cps. Five basic components include: driving head, hydraulic accumulator, high-pressure hydraulic pump, electronically controlled servo valve, and electronic control system. **MB Mfg. Co.,** Div. of Textron Inc., 1060 State St., New Haven 11, Conn.



Circle 637 on page 19

Heat-Sensitive Film

for graphic recording instruments

Heat-sensitive film for graphic recording instruments features easy duplication, projection or optical evaluation. Clear, 100-gage polyester film base provides transparency, extreme stability and resistance to tear. Heated or pressure-loaded stylii render coating transparent. Coated film can be printed with a grid using a high-solvent ink which also changes coat-

Circle 486 on page 19

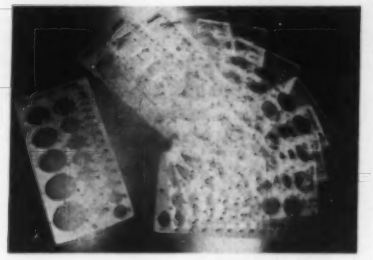
ing from opaque white to transparent. Thus printed and recorded film chart can be duplicated or projected for multiple viewing and discussion. Medium is used to transcribe guided missile data on multichannel pen recorders. Marginal notes, typed without a ribbon, can be duplicated or projected with chart grid and recording. **Technical Paper Co. Inc.**, 2430 Linden Ave. East, Linden, N.J.

Circle 638 on page 19

Ellipse Templates

of matte-finish plastic

No. 70 ellipse series consists of ten templates from 15 to 60 deg in increments of 3 deg with major axes from ¼ to 2 in. Size and center



lines are detailed for permanence on negative side of 0.030-in. matte-finish plastic. Precision cut and individual milling assures smooth, sharp, accurate line. Each template measures 5 by 9⅞ in. **Rapidesign Inc.**, Box 592, Glendale, Calif.

Circle 639 on page 19

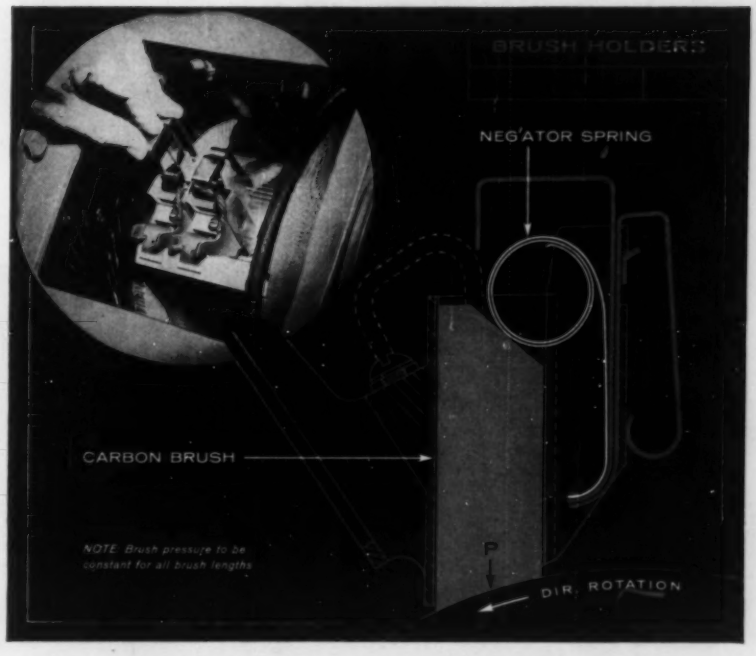
Mechanical Pencils

require no sharpening or lead pointing

Two Fine-Line mechanical lead pencils accommodate 0.031-in. thin lead and weigh less than ½ oz. Requiring no sharpening or lead pointing, they have nonrolling hex-

agonal barrels. Automatic push-button lead ejection makes possible one-hand operation for quick lead adjustment. **Alvin & Co. Inc.**, Windsor, Conn.

Circle 640 on page 19



Maintain Constant Pressure or Tension

USING A NEG'ATOR® SPRING

In the NEG'ATOR Constant-Force Spring, design engineers now have a mechanical component which will *maintain constant pressure or tension over all deflections.*

In vending apparatus, long NEG'ATORS are used to feed merchandise into dispensing position. In a belt grinder, NEG'ATOR Springs counterbalance a motor while keeping the drive belt taut. In a cam follower mechanism, a NEG'ATOR produces desired constant, minimum pressure. In motors and generators, NEG'ATOR Brush Springs keep pressure on carbon brushes at a constant, optimum value to compensate for brush wear.

As illustrated, one of the many design features of the new General Electric Co. KINAMATIC* Motors and Generators are the new brush holders which incorporate NEG'ATOR Brush Springs. By utilizing NEG'ATORS, GE engineers gained the following: (1) unvarying optimum pressure between brush and commutators; (2) elimination of periodic manual adjustments of brush pressure; (3) elimination of spring "hang-up"; (4) a one-piece assembly which is simple to fabricate and easy to assemble into the equipment; (5) easy, one-hand brush removal and replacement without tools.

Wherever applied, NEG'ATOR Springs—used as extension members, long-running motors, as bands, clamps, or clips—have cut costs and improved products. Learn more about this new basic component. Request a copy of Bulletin 310N. Or, if you're interested in NEG'ATOR Brush Springs, write for Bulletin 310P.

*Trade Mark of the General Electric Company

HUNTER SPRING COMPANY

3 Spring Avenue, Lansdale, Pennsylvania

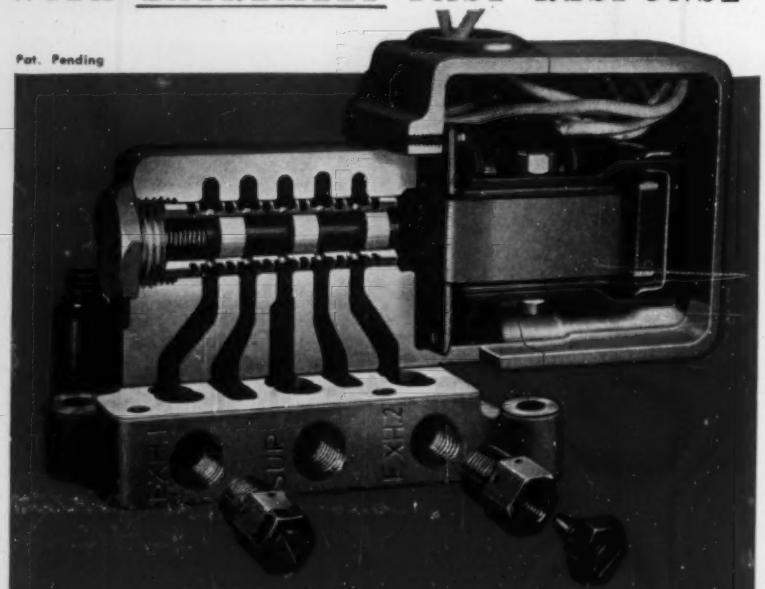
SPRINGS • STAMPINGS • TEST APPARATUS

Circle 487 on page 19

now . . . AIR VALVES

WITH EXTREMELY FAST RESPONSE

Pat. Pending



. . . Almost TWICE As Fast As Ordinary Valves!

The new SA Series single solenoid actuated valves are available in both single and dual pressure models with extremely fast response time. You get total response in 12 *milliseconds*—from energizing to wide open on 60 cycle current. That's almost *twice as fast* as any pilot operated solenoid control valve available today!

All SA Series valves are high performance, full pipe area valves . . . furnished for service on vacuum and air at pressures from atmospheric to 250 psi . . . and at speeds from the most intermittent job in your plant to welding guns. Optional metering valves give simple, sensitive control of piston speed by metering the exhaust air. Exhaust noise is muffled.

The design simplicity of the SA Series valves provides extremely long life and requires a real minimum of maintenance. Only one moving part provides the valving action . . . a corrosion-resistant steel spool and sleeve.

Complete information on the SA Series valves . . . the greatest advance in air controls . . . can be obtained by writing today for your copy of Catalog 8000.

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THE ENGINEER'S Library

Recent Books

Viscous Flow Theory II—Turbulent Flow. *By Shih-I Pai, professor, Institute for Fluid Dynamics and Applied Mathematics, University of Maryland; 277 pages, 6½ by 9 in., clothbound; published by D. Van Nostrand Co. Inc., 257 Fourth Ave., New York 10, N. Y.; available from* MACHINE DESIGN, *$6.75 postpaid.*

The second in a two-volume work on viscous flow theory, this book presents a detailed treatment of the fluid dynamics of turbulent flow. Both semiempirical and statistical approaches are used. Topics include probability distribution, random walk, correlation tensor, spectrum and their applications to turbulence.

Inventor and Inventions. *By C. D. Tuska, Director of Patent Operations, RCA Laboratories; 174 pages, 6½ by 10 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York, N. Y.; $3.75 per copy.*

This manual is intended to stimulate inventive tendencies, and provides suggestions on how to improve creative ability. Included is information on how to protect and patent an invention and practical suggestions on marketing it.

Engineering Thermodynamics. *By C. O. Mackey, W. N. Barnard and F. O. Ellenwood, Cornell University; 428 pages, 6 by 9½ in., clothbound; published by John Wiley & Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from* MACHINE DESIGN, *$7.95 postpaid.*

This book covers the basic principles of engineering thermodynamics including properties and processes of real gases. Later chapters give extended treatment to such topics as one-dimensional flow of ideal gases with area change, friction and heat transfer, properties of mixtures of ideal

gases, ideal gas reactions, energy transformations in turbines, power cycles and real fluids, refrigeration, and air conditioning. The importance of applications of fundamentals is stressed throughout the book.

Digital Computer Programming. *By D. D. McCracken; 253 pages, 6 by 9¼ in., clothbound; published by John Wiley & Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from* MACHINE DESIGN, *$7.75 postpaid.*

This book treats the details involved in working with digital computers. It discusses many points that are troublesome to beginners, and presents basic fundamentals on which to build a sound understanding of programming. As an aid to understanding, a mythical computer has been devised which combines elements from a number of computers now on the market. Parts of the text are applicable to specific machines. A large portion of the text is relevant to any machine.

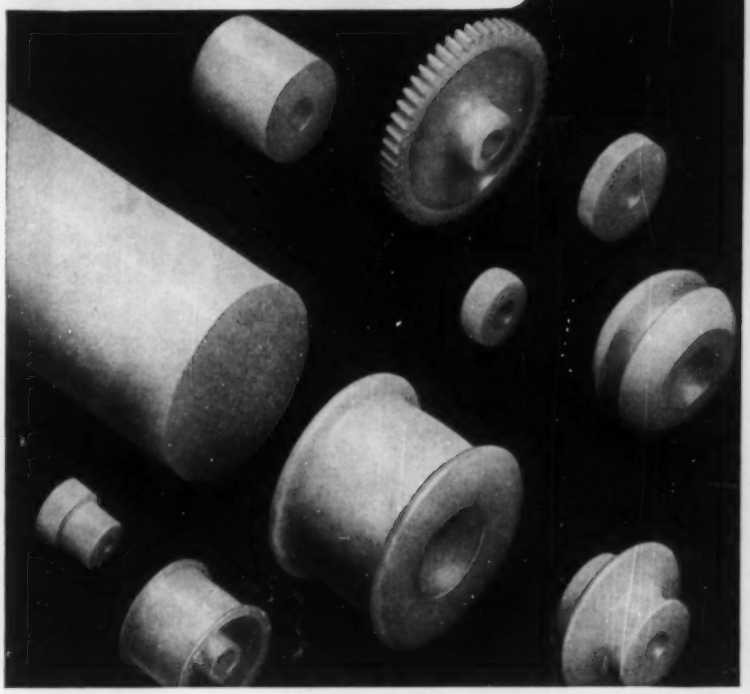
Nuclear Power Engineering. *By Henry C. Schwenk and Robert H. Shannon; 319 pages, 5½ by 8¼ in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York, N. Y.; available from* MACHINE DESIGN, *$6.50 postpaid.*

This book is intended for engineers, technicians and executives concerned with practical power development. It explains nuclear power plants, their design, construction and operation. In addition to engineering methods, information on system components, radiation and its effect on equipment and health, plant sites, and economics of nuclear power production is included. Essential fundamentals of physics are covered as well as detailed design features of reactors. Sequence diagrams explain ideas and procedures, and a description of the power cycle shows integration of power-plant elements.

Manufacturers' Publications

Cold-Rolled Spring Steels. *48 pages, 8½ by 11 in., paperbound; published by and available on letterhead request*

POLYPENCO® NYLON SHAPES



Practical, low-cost solution to nylon parts design: POLYPENCO Nylon Rod

ADAPTABLE Polypenco Nylon rod continues to be the choice of designers who require highest quality nylon *plus* rapid, low-cost production. From the complete range of sizes of Polypenco Nylon rod, it's a quick and economical step to fabricate close tolerance parts and components on standard metalworking tools. Bearings, rollers, thick gears and other parts machined from Polypenco rod have these outstanding properties:

- **Wear resistance**
- **Resilience**
- **Excellent strength to weight ratio**
- **Low coefficient of friction**
- **Noise dampening**
- **Non-galling and non-abrasive to other materials**
- **Chemical resistance**
- **Good electrical insulating properties**

Polypenco Nylon stock shapes are also available in tubular bar, strip, tubing and plate and can be shipped immediately from warehouses located throughout the country. For fabrication of parts, The Polymer Corporation of Pa. maintains a special fabricating service. Write for data on products or services.

THE POLYMER CORPORATION OF PENNA.
Reading, Penna.
Export: Polypenco, Inc., Reading, Penna., U.S.A.

POLYPENCO

POLYPENCO Nylon, POLYPENCO Teflon,† NYLAFLOW® and NYLATRON® GS †DU PONT TRADEMARK

Circle 489 on page 19

Stearns
electro-magnetic
DISC BRAKES
(THE CHOICE OF LEADING MOTOR MANUFACTURERS)

TOUGH... TROUBLE-FREE AS A BRAKE CAN BE!

When you're looking for a brake to stop motors quickly . . . cut waste time . . . step up production cycles per hour per machine, consider these six outstanding features of Stearns electro-magnetic Disc Brakes.

1 **SMOOTH-OPERATING MECHANISM** — Linkage from the solenoid operates smoothly on bearings to reduce wear on sliding surfaces. This means long life — trouble-free service.

2 **RUGGED CAST CONSTRUCTION** — To give you strength and rigid stability that long, hard industrial service demands, Stearns Brakes feature cast construction of enclosures and many components. Pleasing and functional contours blend naturally with smooth lines of the electric motors to which they are coupled.

3 **MAXIMUM SAFETY FACTORS** — The highest mechanical and electrical safety factors — a result of advanced design and engineering, proved by exhaustive testing and field operation assure consistent satisfactory performance even under most adverse conditions.

4 **A MAINTENANCE MAN'S "DREAM" UNIT**—The only brakes with visual wear indicators and simple installation. A screw driver is your complete Tool Kit for Stearns Brakes. Convenient electrical connections. Long-life friction lining, which seldom requires replacement, can be quickly and easily changed, when needed.

5 **FAST STOPS — QUICK RELEASE** — Positive spring action on pressure plates for fast, smooth stops—setting brakes automatically in case of power failure. Instantaneous magnetic pull provides quick release — eliminates drag.

6 **A SIZE AND TYPE FOR YOUR APPLICATION** — Over 150 standard sizes and types available to fit re-rated NEMA motor frames in sizes ranging from 1/20 to 100 hp, AC or DC. Maximum torque ratings from 0.6 to 7,500 lb ft. Vertical, horizontal, motor or floor mountings. Stub or thru-shaft design. Housings for explosion-proof, dust and waterproof, or standard operation.

For complete magnetic brake data, call your local Stearns representative or send direct for Brake Portfolio F.

BRAKES MILWAUKEE Stearns WISCONSIN CLUTCHES
ELECTRIC CORPORATION
120 NORTH BROADWAY • MILWAUKEE 2, WISCONSIN

Library

from Associated Spring Corp., Wallace Barnes Steel Div., Bristol, Conn.

This booklet is a brief text on the whole subject of spring steel—its essential qualities, the various grades and what each is most commonly used for, how it is rolled, annealed, split, hardened and tempered, polished, colored, and inspected. The book includes a technical discussion of hardness values, selection of analyses and grain structure, as well as design and fabrication data.

Transistor Manual. *61 pages, 5½ by 8½ in., paperbound; published by and available from General Electric Co., Semiconductor Products Dept., Syracuse, N. Y.;* 50c *per copy.*

This booklet is designed to assist the design engineer in working with transistors. It includes information on basic semiconductor theory, construction techniques used to make the various types of transistors now on the market, basic principles of transistor circuit design, and specifications, with outline drawings, of all transistors registered with the Radio-Electronic-Television Manufacturers Association. The booklet also contains explanations of transistor-parameter symbols now in use.

Government Publications

Technical Manual on the Machining of Thermanol, PB 121660. *23 pages, 8 by 10½ in., paperbound; available from Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C.;* 75c *per copy.*

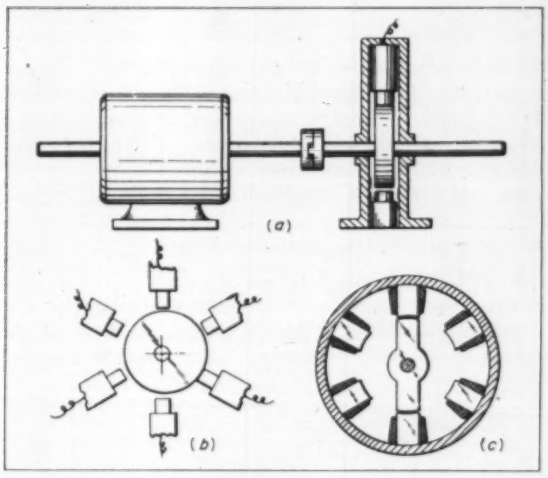
Machining of Thermanol, a new aluminum-molybdenum-iron alloy is described in this manual. Cast specimens of the material were machined by processes and methods currently used in industry to produce commercial finishes. Methods included parting, turning, boring, threading, shaping, drilling, tapping, and milling. Thermanol, developed by the Naval Ordnance Laboratory, is an alloy of superior high-temperature, noncorrosive and magnetic properties and is 20 percent lighter than iron. Its development is receiving attention because of nonstrategic components.

NOTEWORTHY

Patents

Torque-Amplifying Rotary Positioner

Rotational input at low torque level is converted to high-torque output by a positioner with torque-amplifying characteristics. Components are a cam-operated



switch with multiple contacts (*a*, right) coupled to a multiple field pole motor (*a*, left). Rotation of the input shaft sequentially actuates the switch contacts (*b*) which, in turn, energize opposing field poles of the motor (*c*). Because mechanical coupling of switch to motor is loose (30-deg backlash in model shown), input torque need only be high enough to overcome switch friction torque. Fail-safe operation in event of power failure is assured, since input and output shafts are directly coupled. Typical applications are coarse or fine shaft positioning, or in "zeroing in" control adjustments. *Patent 2,790,124 assigned to Reflectone Corp. by William A. Eisele.*

Magnetic Motion Converter

Almost loss-free conversion of rotary to reciprocating motion, or vice versa, is the function of a motion converter with magnetically coupled components. In typical form (center view), rotation of the input shaft (left center) magnetically translates the output shaft. Translation of the input shaft is blocked by the bearing arrangement; rotation of the output shaft is stopped by the spring-mounting system. Arrangement of the annularly positioned magnets, which are axially polarized, is shown in the left view. An alternate version of the device, in which the translating element is diaphragm supported, is illustrated at right. In a typical converter, where the diameter of the magnetic circle is 12 cm, an axial force averaging

MOLDED SEAL RING
(ACTUAL SIZE)

LUBRICATION A PROBLEM? . . .

why not try Purebon*

* CARBON-GRAPHITE ESPECIALLY DESIGNED FOR MECHANICAL APPLICATIONS

Where lubrication is a problem on bearings, seals, blades and similar sliding or rotating parts, Purebon is often the ideal solution.

PROPERTIES OF PUREBON

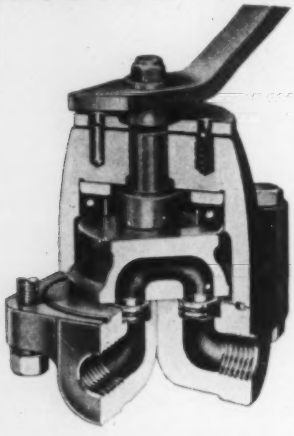
1. Moldable to size.
2. Readily machineable.
3. Chemically inert.
4. Dimensionally stable.
5. Light weight.
6. Low cost where moldable to size.

For complete information about PUREBON write for new Bulletin No. 55, or see Sweet's Product Design File

PURE CARBON CO., INC.
442 HALL AVENUE ST. MARYS, PENNSYLVANIA

Circle 491 on page 19

DO YOU **CONTROL** YOUR HI-PRESSURE CIRCUITS?



1. *Can you shut off flow tightly?*
2. *Can you throttle gradually?*
3. *Can you get full flow?*

1 **MANUAL "SHEAR SEAL" VALVES**

(1500, 3000 and 6000 P.S.I.)
are leakproof and stay leakproof for years of service with little or no maintenance; no internal port to port leakage in the detented positions and, of course, no external leakage. Sealing qualities actually improve with use, due to wear compensating lapping action of "Shear-Seals."

2 You get excellent throttling, smooth action to any degree of flow without fighting the fluid pressure.

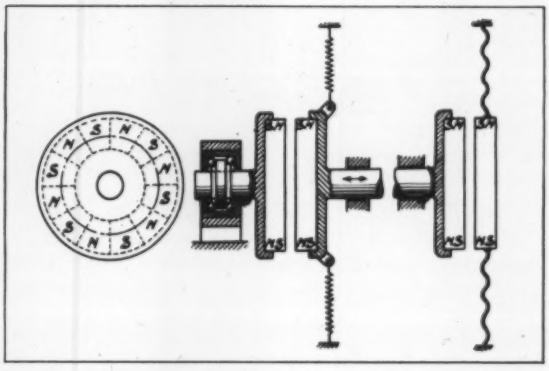
3 Quick as a quarter turn of the handle you can open the full flow (or shut it off) with surge dampening action, because the round tubular passages have no spools or poppets obstructing flow.

BARKSDALE VALVES

5125 Alcoa Avenue, Los Angeles 58, California

Ask for bulletin 5-H, -A and -W.

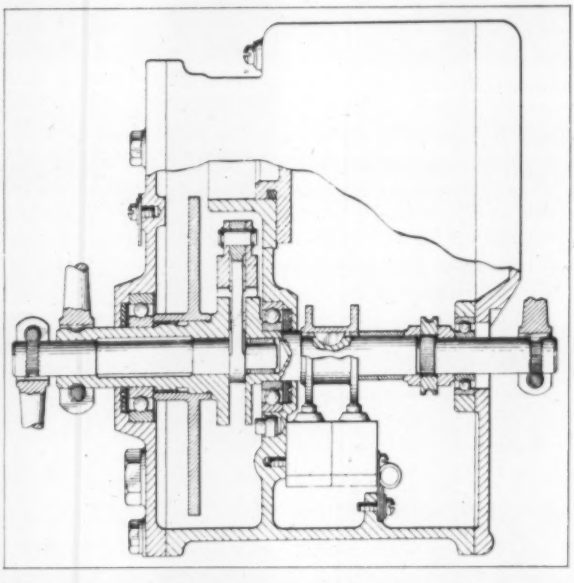
Noteworthy Patents



10 kg is produced with an air gap of 2 mm. Magnitude of the force developed makes the device suitable for actuating diaphragm pumps, filing, grinding, polishing and similar applications. *Patent* 2,790,095 *assigned to North American Philips Co. by Johannes Peek and Johannes Cluwen.*

Mechanical Motion Discriminator

Designed to connect either of two input or driving sources to a single output shaft, a mechanical discriminator operates in such a manner as to move the output shaft with whichever input shaft is farthest



advanced from a datum position. Either driving member can be advanced independently of the position of the other. One field of use of the discriminator is to provide for normal operation or control of the driven unit by one driving member, and to provide overriding control by second driving member. *Patent* 2,778,241 *assigned to General Motors Corp. by Arthur W. Gaubatz.*

Copies of patents briefed in this department may be obtained for 25 cents each from The Commissioner of Patents, Washington 25, D. C.

HERE'S ACTUAL PROOF!!

Versatility of Mechanical Seals Proved by SEALOL . . .

The SEALOL BALANCED PRESSURE SEAL, incorporating the differential area principle, has proved unusually versatile and efficient in rotary shaft sealing applications of all kinds. If your particular sealing requirements are not listed among the actual sealing applications tabulated here, request Bulletin 7 for complete data.

RPM	Shaft Size	Temperature	Fluid	Pressure
36,000	¾"	200° F	Aviation Fuel	300 PSI
1,800	1⅛"	Room Temp.	Ucon Hydraulic Fluid	1500 PSI
11,000	2¼"	200° F	Lube Oil	20 PSI
6,800	5"	125° F	Lube Oil	Atmos. Pressure
80	2¾"	350° F	Steam & Hot Air	Atmos. Pressure
7,700	5¼"	350° F	Lube Oil	2 PSI
53,000	1"	350° F	Oil & Steam	350 PSI
70,000	½"	230° F	Oil Mist & Air	19" Hg. abs.

Slightly modified versions of the basic Sealol seal make it suitable for almost any rotary shaft sealing application.

RPM	Shaft Size	Temperature	Fluid	Pressure
12,000	2¼"	−300° F	Liquid Oxygen	250 PSI
30,000	1⅛"	125° F	90% Hydrogen Peroxide	60 PSI
14,000	1¾"	160° F	Fuming Nitric Acid	200 PSI
10,000	⅜"	300° F	Propyl Nitrate	150 PSI

Write us today about your particular problem. Request Bulletin 7 or send blueprints and specifications for speedy Sealol seal-utions. Write now!

SEALOL CORP

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SEALOL

THE BALANCED PRESSURE SEAL

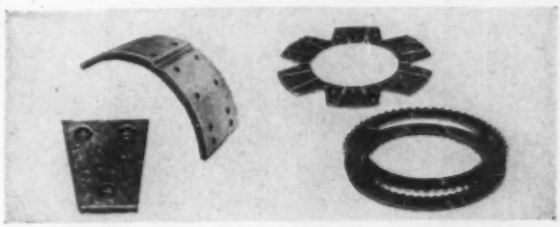
Circle 497 on page 19

You can't BUY it until we TRY it

Few engineers have had the pleasure of seeing a new design spring into production without bugs. Many have been wounded by bugs that survived exhaustive lab tests, and emerged in production quantities on the road. American Brakeblok's on-the-road fleet testing prevents this painful experience.

To insure complete design confirmation, pilot production samples are subjected to field service conditions in cars and trucks completely instrumented to furnish comprehensive test reports. In addition, American Brakeblok's nationwide field service engineering is available to assist in your own evaluations.

For a complete picture of American Brakeblok service, send for the 20-page brochure, *Taming Dynamics with Engineered Friction*. Good reading.



Asbestos-based Sintered metal friction material

American Brakeblok
FRICTION MATERIALS

AMERICAN Brake Shoe COMPANY

AMERICAN BRAKEBLOK DIVISION
DETROIT 9, MICHIGAN

Circle 498 on page 19

COES KNIFE COMPANY

Precision Ground Machine Ways

Hardened tool steel ways, guides, and special wear plates, inseparably forge welded to tough, machineable backings. Hardness, shapes, dimensions, and mounting holes to your specifications.

For quotations, send sketches of your requirements to:

COES KNIFE COMPANY, 64 COES ST., WORCESTER, MASS.

MACHINE KNIVES

Standard and special blades of solid or composite steel, for all machine knife applications.

COES MICRO GROUND

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Design Manual

"MECHANICAL ADJUSTABLE-SPEED DRIVES"

Parts I & II
by Leo F. Spector

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Circle 500 on page 19

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a division of The Carpenter Steel Company

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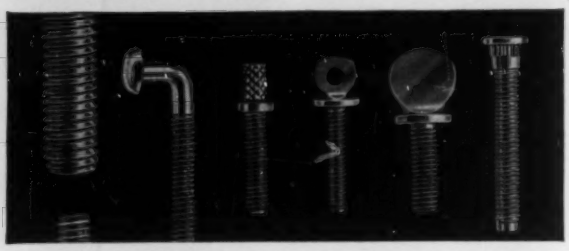

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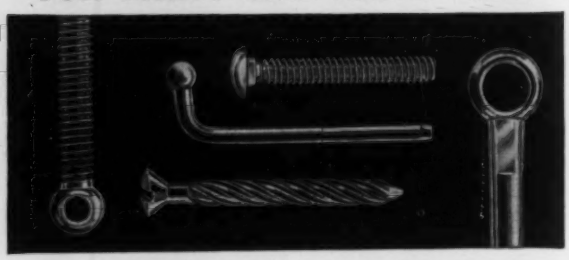

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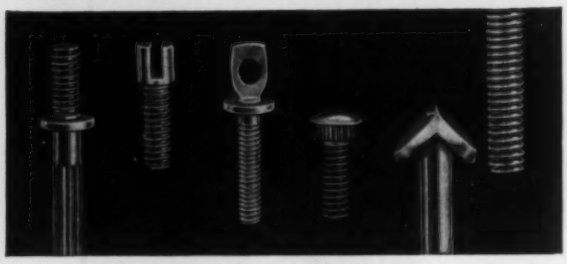

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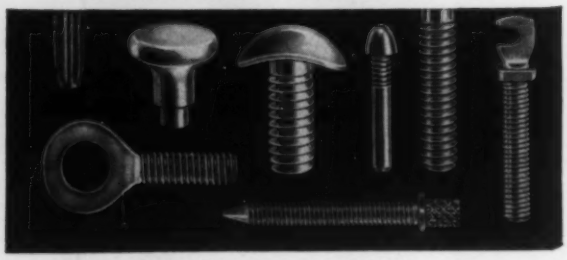

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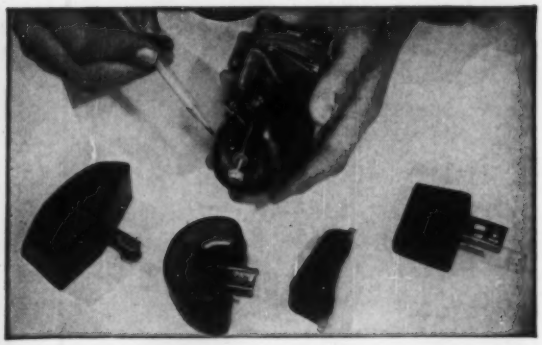

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Parker
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for coiled tube

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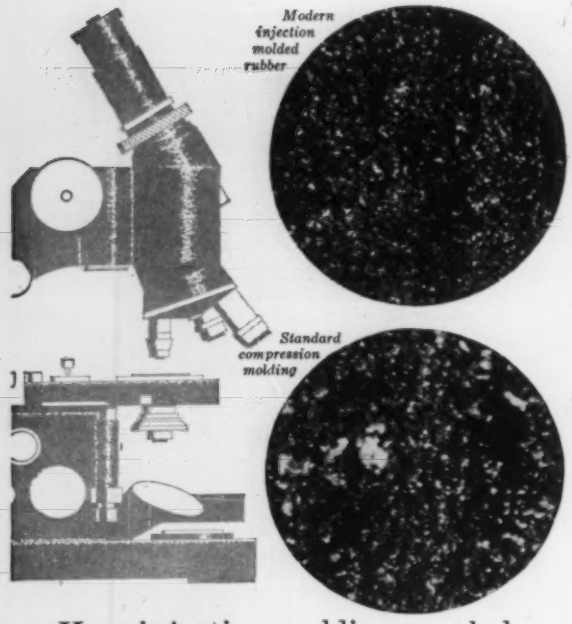

How injection molding can help you solve design problems, improve products with rubber parts . . .

Greater density produced by injection molding is shown in comparison to ordinary compression molding. Injection molded rubber (top) displays homogeneous characteristics unequalled for consistency or toughness by any other process. In application this will mean tremendous resistance to abrasion and chemical action—much longer rubber part life. Both microphotographs are standard Buna N compound, approx. .269″ x .019″, magnified 240 diameters by the University of Minnesota.

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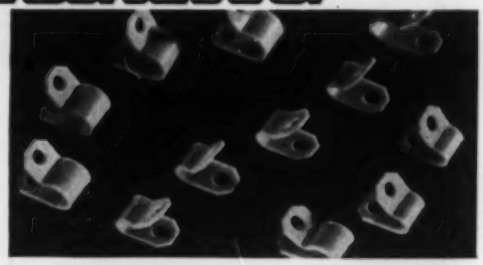

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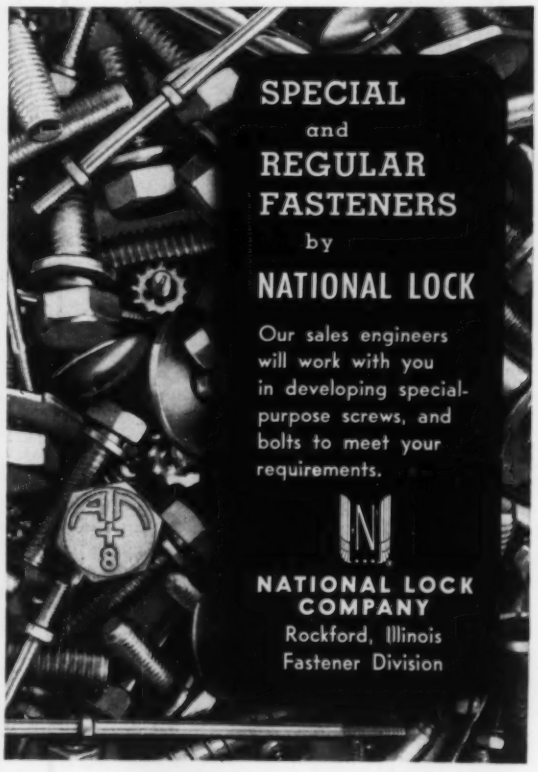

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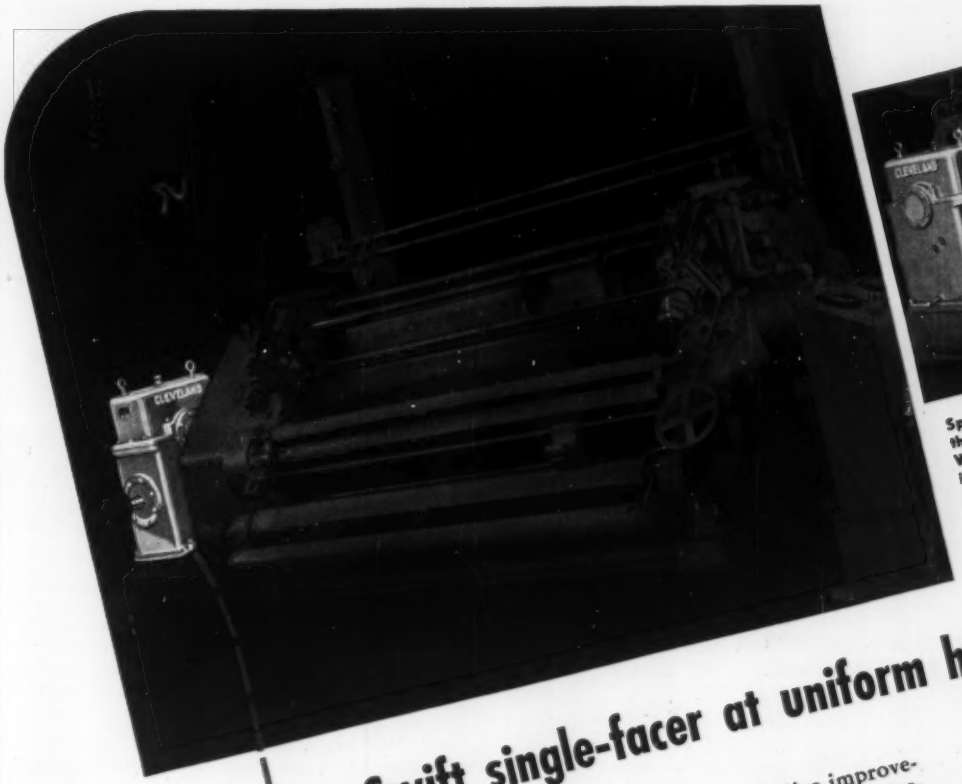

Space-saving feature of the right-angle Cleveland Worm Gear drive is well illustrated here. Note how reducer and motor literally hug the driven machine

CLEVELAND drives Swift single-facer at uniform high speed

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Affiliate: The Farval Corporation, Centralized Systems of Lubrication, In Canada: Peacock Brothers, Limited.

CLEVELAND
Worm Gear
Drives

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CUTLER-HAMMER

MOTOR CONTROL

C-H

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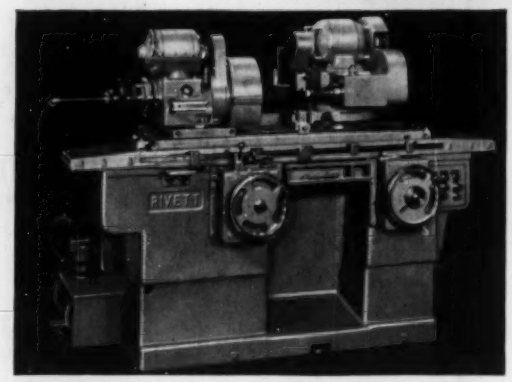

THE RIVETT 1024 INTERNAL AND UNIVERSAL GRINDER MADE BY RIVETT LATHE AND GRINDER INC., INCLUDES CUTLER-HAMMER THREE-STAR MOTOR CONTROL AND NEW OIL-TIGHT PUSH-BUTTONS.

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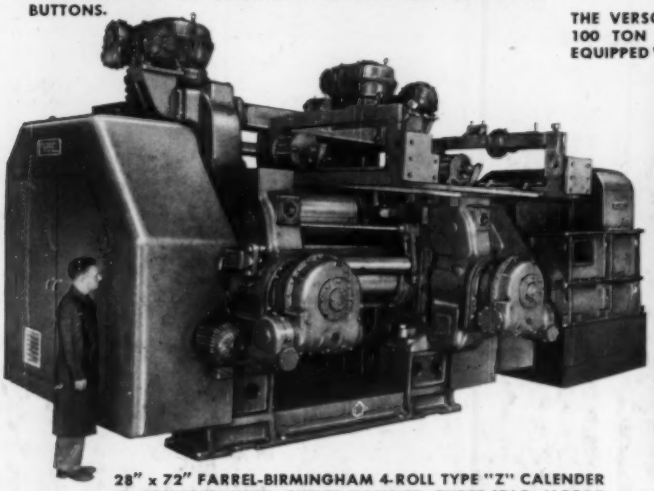
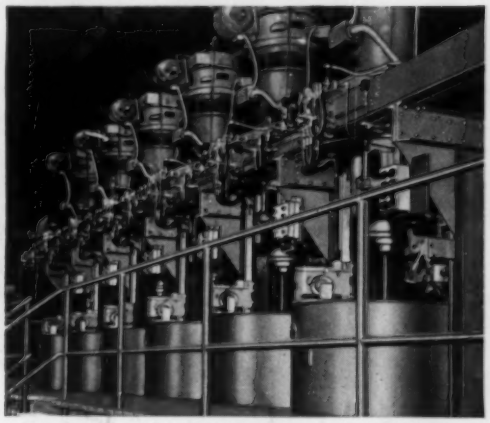


28" x 72" FARREL-BIRMINGHAM 4-ROLL TYPE "Z" CALENDER IS EQUIPPED WITH CUTLER-HAMMER THREE-STAR MOTOR CONTROL AND HEAVY DUTY OIL-TIGHT PUSHBUTTONS.



THE WESTERN STATES MACHINE COMPANY INSTALLS CUTLER-HAMMER THREE-STAR MOTOR CONTROL ON THEIR ELECTRICALLY DRIVEN CENTRIFUGALS.

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There is no such thing as the manufacturer of a bad product in American industry; competition is too keen for such a company to live. But there are degrees of merit. Among machinery builders, there are those whose products are accepted as being better than others, and a few whose machines are widely recognized as the best. These machinery builders are the acknowledged leaders in their field . . . *they have no equal.* This position of leadership was not easily won nor is it held without constant attention to every detail which influences the product's performance. It is most significant that so many of these leaders standardize on Cutler-Hammer Three-Star Motor Control as original equipment for their machines . . . *the stars have no equal.* Machinery buyers find Cutler-Hammer Motor Control a reliable guide to greater value and satisfaction. CUTLER-HAMMER, Inc., 1310 St. Paul Ave., Milwaukee 1, Wis. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto.

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